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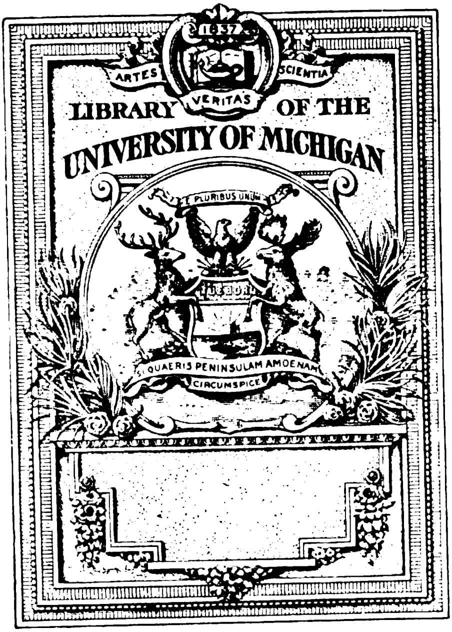

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Bulletin No. 36. October, 1896.

FLORIDA
AGRICULTURAL EXPERIMENT
STATION.

INSECTS INJURIOUS TO STORED GRAIN AND CEREAL PRODUCTS.

BY

A. L. QUAINTANCE.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

JACKSONVILLE, FLA.:
DACOSTA PRINTING AND PUBLISHING HOUSE,
1896.

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INSECTS INJURIOUS TO STORED GRAIN AND CEREAL PRODUCTS.

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GENERAL REMARKS.

The ravages of insects in stored grain and cereal products in Florida are particularly severe. That this is true, is at once understood from the fact that our climate allows of a very long, and doubtless with many species, an uninterrupted breeding season. Grain stored away in the fall may become so badly infested by spring that its value as feed is greatly reduced, and for seed purposes it is quite worthless. The weight of grain infested with insects soon becomes greatly reduced from the fact that the nutritious substance has been eaten out, leaving the empty hulls. Observations that have been made, on grain infested by the Angumois grain moth for six months, show that it sustained a loss of fifty per cent in weight, and seventy-five per cent in its farinaceous matter. The example of the work of this one insect alone, will serve to give some idea of the great loss sustained by farmers and dealers, from grain infesting insects.

According to Hon. L. B. Wombwell, Commissioner of Agriculture, the corn crop in Florida for 1893 was 3,403,728 bushels, valued at $2,462,890.75. From extended observations we believe that fully twenty per cent of all the corn stored in granaries is destroyed by insects. If the above figures on the yield and value of the corn crop of Florida be entirely correct, it is seen that our annual loss becomes exceedingly great. Twenty per cent of $2,462,890.75 is $492,598.15. This will indicate approximately the yearly loss sustained by the farmers and grain dealers of this State. Corn, however, is not the only crop that is attacked. Rice, cow-peas, oats, beans, peas, peanuts, cotton-seed, flour, corn-meal, grocery produce, and many other substances are quite as subject to the attack of insects, as corn. It is thus seen that the total annual loss from these insects becomes very great.

The question at once arises, is there no remedy against these insect pests? Fortunately, there is. The carbon bisulphide remedy has been used with the best of success against all kinds of insects infesting stored grain and cereal products. This is a cheap and efficient remedy, and when properly used will give perfect satisfaction. Under the head of TREATMENT, on page 382, will be found complete directions for its purchase and use.

In the following pages it is desired to give brief descriptions, with the life-history of the more important grain insects to be found in this State. In most cases figures are given illustrating the different stages in their life-history, which is hoped will greatly facilitate their recognition.

THE ANGUMOIS GRAIN MOTH.

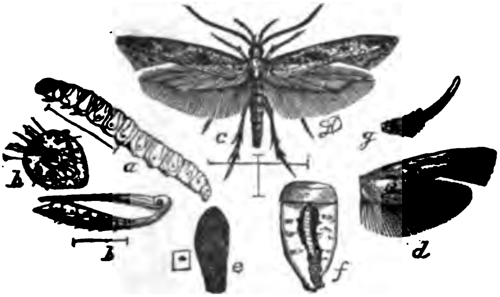

Fig. 1.—*Gelechia cerealella*; Oliv.: a, larva; b, pupa; c, female moth; e, egg; f, kernel of corn showing larva within—all enlarged except f.

This insect is very abundant in this State, and is one of the most serious pests to stored grain that we have. Several granaries which were visited during the month of August of this year were found to be most badly infested, and corn stored the previous fall was almost worthless from the ravages of this insect and the rice weevil. The Angumois grain moth is thought to be indigenous to the region of the Mediterranean sea. It derives its name from the French Province Angumois, where it was at one time particularly injurious. The earliest notice we have of this insect is in 1736, when it was noted by Reaumur as injuring stored barley in France. In the United States it occurred in North Carolina as early as 1728. Since this early date of its occurrence in North Carolina it has spread quite generally over the Southern States, where its ravages are most severe. The food of the Angumois moth in America is quite varied, but corn and wheat suffer most from its ravages. In this State the injuries are confined chiefly to corn and cow-peas.

DESCRIPTION.

The *adult* is a small moth, having a wing expanse of about one-half of an inch. Its body and fore-wings have a soft, shiny, light gray color, while the hind-wings are darker and bordered with a long, delicate fringe. The ventral surface of the body and the wings are darker than the dorsal surface, while the legs are somewhat darker than the body, the caudal pair being hairy, and provided with spurs. For an illustration of the moth enlarged, see fig. 1, c. The hair lines below indicate the natural length and wing expanse.

The *larva*, illustrated in fig. 1, a, is, when full grown, nearly one-fourth of an inch in length, of a light color, provided with numerous hairs, which on the first and last segments are somewhat longer than elsewhere. In general form the body is cylindrical, gradually tapering caudad from the second segment; the head is brown. Fig. 1, f, shows the larva at work in a kernel of corn, natural size.

The *egg* is illustrated at e, greatly enlarged; it is somewhat oval in form, and of a pale red color.

The *pupa* shown at b, is about one-fourth of an inch long, brownish in color, with the abdominal region of a somewhat lighter shade.

LIFE HISTORY AND HABITS.

The eggs are deposited on the grain, either in the field or in the granary. They are placed in the ears of corn, between the rows of seed, or at their bases under the thin membranes. They may be found either singly or in clusters of twenty to thirty. In the course of a few days the eggs develop into small, active larvæ, which at once eat into the grain, devouring the starchy matter, eventually leaving but a thin empty shell. Two, three, or more larvæ may be found within a single kernel of corn, but the smaller cereals usually afford food for but one. The length of time of the larval stage is usually four or five weeks, although this varies somewhat with the temperature.

When the caterpillar has attained its growth it bores a small hole to the exterior of the kernel to allow of its escape as a moth, and then passes into the pupa state within the seed. The pupa state lasts from a few days to weeks, depending upon the temperature. The entire life cycle from egg to adult is, in this climate, about five weeks. The moths mate soon after emerging from the crysalis, and deposit a laying of eggs. There appears to be no regular time for the appearance of the adults, as all stages may be found at almost any time in the infested grain. This rapid fecundity soon enables them to bring about the destruction of the grain. In the Gulf States doubtless as many as eight broods are raised each year.

Corn that has not been husked is much freer from the attack of this insect than corn that has been husked or shelled.

Fig. 2 represents an ear of popcorn showing the work of this insect. Grain may be badly infested with larvæ and appear to be sound,

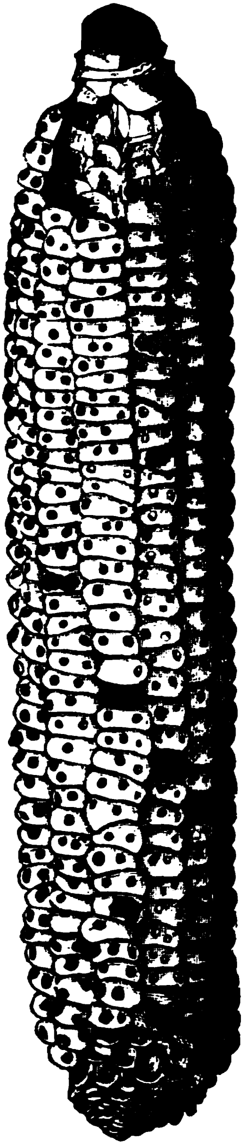

Fig 2.—An ear of popcorn illustrating the work of the Angumois grain moth

as the excrement from the larvæ may fill up the small holes through which they entered; but it may be easily detected when grain is infested from its lighter weight. If a few seeds are thrown into water, the infested ones will not sink as will the sound ones.

TREATMENT.

For the treatment of this and the other insects attacking stored grain considered, see the directions for treatment at the close of this bulletin. Since the treatment for the various grain infesting insects is the same in all cases, it is useless to repeat it for each species.

THE MEAL SNOUT-MOTH.

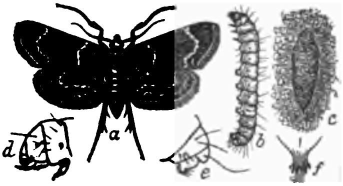

Fig. 3.—*Pyralis farinalis,* Linn.: a, moth; b, larva; c, chrysalis; all natural size.

The meal snout-moth is well known in Europe where it is a great nuisance. In this country it is gaining quite a foothold, and may ultimately become a serious pest.

Like the Indian-meal moth and flour moth the larvæ of this insect make long tubes, by fastening together small particles of food with silken threads which they secrete. In these tubes they live, feed and go through their transformation. The meal moth feeds upon various cereals, and their products. It is said to even attack straw and hay. I am not aware of the occurrence of this insect in Florida. It is liable to be introduced at any time, and become of considerable trouble.

DESCRIPTION.

In fig. 3, a, the *moth* is shown natural size. The general color is light brown. The fore-wings are marked on their basal and distal parts with patches of dark brown. Across each fore-wing are two wavy, whitish lines.

The *larva* and *pupa* may be seen in fig. 3, b, and c; d, illustrates the head of the larva enlarged.

THE MEDITERRANEAN FLOUR MOTH

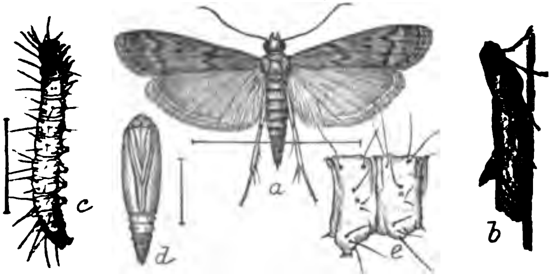

Fig. 4.—*Ephestia keuhniella*, Zell.: a, moth; b, same from the side; c, larva; d, pupa, all enlarged.

This insect first became noted as a pest in 1877, when it was found to be doing much damage in a flour mill in Germany. From Germany it spread into Holland and Belgium and later appeared in England. In 1889 it appeared in the Dominion of Canada. It has recently been reported from North Carolina, New Mexico, Alabama, Colorado, Chile, and Mexico. From this it is evident that it is becoming quite generally distributed. Although it has probably not yet appeared in this State, it may be expected any time.

DESCRIPTION.

The *adult* is a grayish colored moth having a wing expanse of about one inch. The fore-wings are marked with transverse black lines, as shown in fig. 4, a. The hind-wings are of a dirty white color with a darker border. At b, fig. 4, the moth is seen from the side.

The *larva* is worm-like, about one-half inch long. The head is dark brown, and the body provided with bristle-like hairs as shown in fig. 4, at c. The *chrysalis* is represented at d fig. 4; e, shows an abdominal joint of the larva, showing arrangment of spines.

LIFE HISTORY AND HABITS.

About five weeks are required for this insect to pass through all its stages from the egg to the adult. In the latitude of Washington there may be six or more generations a year. In the Southern States, doubtless more than this may be raised, and it is quite probable that breeding may continue uninterrupted throughout the year. In some places where this insect is known, it has created such havoc that it has been called the scourge of the flour mill. The larvæ live in silken tubes which they spin through the grain or flour, and it is this habit that renders them so injurious. These webs cause a felting together of the flour which clogs the machinery, causing frequent and protracted delays. This caterpillar seems to prefer flour or meal, but it will also attack other cereal products.

THE INDIAN-MEAL MOTH.

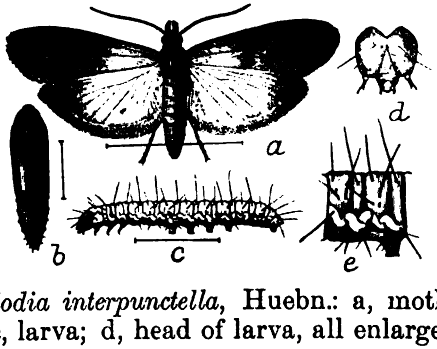

Fig. 5.—*Plodia interpunctella*, Huebn.: a, moth; b, chrysalis; c, larva; d, head of larva, all enlarged.

The Indian-meal moth is another serious pest to stored grain and cereal products in this State.

The moths were found to be very abundant in the granaries visited the present summer. They were observed among the ears of corn in considerable numbers. Twenty-six moths were counted on the inside of a barrel that contained a few inches of shelled corn on the bottom. So far as my experience goes, its ravages in this State are almost equal to those of the grain moth and granary weevil. I have bred it from flour, dried apples, dried peaches, sweet-corn, field-corn, grits and corn-meal. In the latter it was particularly abundant. Corn-meal set aside for a few weeks becomes badly infested. Besides the above mentioned products which it infests, it is recorded as infesting nuts, condiments, sugars, jellies, yeast-cakes, herbs, roots, millet, all kinds of dried fruits, raisins, prunes, and pea-nuts. In fact it may be said that almost any kind of edible is subject to its attack.

DESCRIPTION.

The *adult* is a small moth of the family *Phycitidæ*, to which family also belongs the Mediterranean flour moth just referred to.

The indian-meal moth has a wing expanse of about five-eighths of an inch. The basal one-third of the forewing is of a dirty white, while the distal portion is reddish brown. The body is rather stout for moths of this group. See fig. 5. a, enlarged.

The *larva*, or worm, is a small whitish insect, with brownish yellow head, living within the silken tubes which it spins through the meal, dried fruit, or other material which it may infest. In fig. 5, c, the larva is illustrated much enlarged. At d, the head is shown, while e, represents the enlarged first abdominal segment, showing the arrangement of the spines, which is of great importance in recognizing this species from others nearly allied. The *pupa* is illustrated at b; it is seen to be a capsule shaped body about three-eighths of an inch in length. The wing-pads and antennæ are distinctly visible on the ventral surface.

LIFE HISTORY AND HABITS.

The eggs are laid by the moth in the material on which the larvæ feed. The larvæ spin silken tubes through the food, and in these they live and finally undergo their transformation. Infested meal becomes clotted and lumpy from these silken threads binding the grain together. The life cycle from egg to adult is completed in about one month, which being so short, allows of many generations during the year. This insect probably breeds continuously throughout the year in the greater portion of our State.

THE GRANARY WEEVIL.

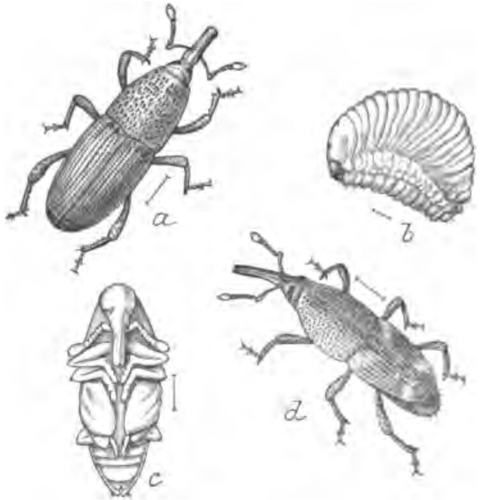

Fig. 6.—*Calandra granaria*, Linn.: a, adult; b, larva; c, pupa; d, *Calandra oryza*, adult. Hair lines represent natural length.

This insect is doubtless native to the Mediterranean region where it probably was known before the Christian era. Having been domesticated for so long a time, it has now lost the use of its wings, which are present only as rudiments, and cannot function for flight. In Florida the granary weevil is not sufficiently abundant to be the cause of much damage. It has been found infesting corn, cow-peas, flour, corn-meal and rice.

DESCRIPTION.

The granary weevil is one of the true grain weevils of the family *Calandridæ.* It is a short, stout-bodied beetle, being about one-seventh of an inch long. The thorax is marked with punctures arranged longitudinally as shown in fig. 6, a. From the head there projects, in front, a long snout-like proboscis, bearing the mandibles, and a pair of elbowed antennæ. The body is hard, and of a uniform chestnut-brown color. See fig. 6, a, enlarged.

The *larva* of this beetle is illustrated at b, fig. 6. The *pupa* is shown at fig. 6, c.

LIFE HISTORY AND HABITS.

The eggs are deposited singly in the grain. The female punctures the grain with her snout, and in this cavity places an egg. The egg hatches into a very small, white, footless grub, which eats further into the grain, and in which it attains its growth and completes its transformation, emerging as an adult. In the smaller cereals but one larva occupies a single grain. In a grain of corn however, food is found for several. In the Southern States six or more broods are probably raised annually. According to Mr. Chittenden, Assistant Entomologist, United States Department of Agriculture, the time required for the completion of the life cycle from egg to adult in the lalitude of Washington is forty-one days. The length of time of the life cycle varies much according to the season and climate. The granary weevil is injurious, both in the larval and adult stages.

Flour made from badly infested wheat, according to Dr. Riley, has been the occasion of much suffering, and even death.

THE RICE WEEVIL.

(*Calandra oryza*, Linn.)

The loss caused by the work of this insect in Florida equals, if it does not exceed that caused by the Angumois grain moth. Together they are responsible for the greater part of the injury done to stored grain.

The rice weevil takes this name from the fact that it was first found in rice, but the name is rather misleading, in that it feeds upon many kinds of grain and cereal products. It is doubtless indigenous to India, from where it has become well distributed through commercial relations, to many grain-growing parts of the globe. It was brought to America from Europe, and it now enjoys quite a general distribution in this country, where it is to be found in every State and Territory, including Alaska. Its ravages in the North, however, are not so severe as in the South.

DESCRIPTION.

The rice weevil bears a close resemblance to the granary weevil, both in size and appearance. It is somewhat smaller, however, and differs from it, in that it is of a dull brown color, and in having the wing-covers marked with a reddish colored spot on each corner as shown in fig. 6, d. The thorax of this species is densely marked with pits. On the wing-covers the pits are arranged longitudinally. As with the granary weevil the head bears a snout, on which are born elbowed antennæ.

The *larva*, when full grown, is about one-eighth of an inch long, footless and fleshy, being quite similar to the larva of the granary weevil.

The *pupa* is whitish, about an eighth of an inch in length, very much resembling that of the preceding species.

LIFE HISTORY AND HABITS.

In this State this insect does more damage to corn than to other cereals. It is to be found in the field early in August. But it is when the corn has been gathered and housed, however, that the rice weevil does its greatest damage; here in the warm atmosphere it breeds rapidly, both larvæ and adults sharing in the work of destruction. Eggs are deposited by the female in punctures made in the kernels with their long snouts. But a few days are required for them to hatch into grubs. From three weeks to two months are required for this insect to pass through its life cycle, depending upon the season. Corn infested with this weevil has been reported as injurious to stock when fed, and it is not improbable that meal made from infested corn would be seriously injurious to man.

THE BEAN WEEVIL.

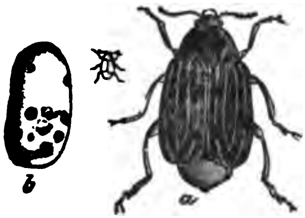

Fig. 7.—*Bruchus obtectus,* Say.: a, adult beetle; b, infested bean. Natural size indicated by small figure.

This bean weevil and the four-spotted weevil are both quite abundant in this State, and are frequently thought to represent but one species. The bean weevil is probably an imported enemy, and has now become quite well distributed over the greater part of the United States. As early as 1860 it was noticed that it was attacking the bean. It is a serious pest to this crop in the field and when harvested.

DESCRIPTION.

The *adult* is a small beetle about one-tenth of an inch in length, ashy black, with a slight brownish tinge. The body is quite hard and somewhat flattened. See fig. 7, a.

The *larva* is a small, soft-bodied, grub-like insect, passing its entire life in the bean. An infested bean is illustrated at fig. 7, b.

LIFE HISTORY AND HABITS.

Recent observations by Prof. Slingerland correct the heretofore accepted statement that the eggs of this species are deposited on the outside of the pod. His observations show that the eggs are placed *inside* of the pod, the adults gnawing a narrow slit along the ventral suture, through which the ovipositor is thrust and the eggs deposited. No doubt the eggs are sometimes deposited on the outside of the pod, but it is probable that such cases are accidental, and that the eggs are frequently destroyed before hatching. Several eggs may be deposited at one place. In about two weeks these hatch, and the larvæ eat into the beans. Several may occupy one seed, but each having its separate cavity. The germ is rarely injured, it being avoided as if it were distasteful. The larvæ reach maturity in the latter part of the summer, and transform into pupæ in the fall. Some of the beetles emerge in the fall while others do not appear until the following spring, when they deposit eggs again in the young and tender pods.

In stored beans the eggs are laid on the outside of the beans, loosely attached. Many successive generations may be raised in stored beans.

THE CHINESE COW-PEA WEEVIL.

(*Bruchus chinensis*, L.)

This pest has been reported as doing much damage to cow-peas in this State. During the late spring of the present year some "wormy" cow-peas were received from a correspondent, which proved to be infested with the Chinese cow-pea weevil. These were set aside to await development. On August eleventh it was found that sixty-one beetles had been bred from seventeen small cow-peas. This indicates their fecundity and rapidity of development. The peas were quite badly eaten, as many as six and seven weevils having been bred from a single pea.

DESCRIPTION.

The *adult* is about one-eighth of an inch in length, and quite robust; the wing covers are reddish brown, mottled, more or less, with a lighter shade, with the prothorax and head darker. It bears a general resemblance to the pea and bean weevils, but the body is stouter.

THE FOUR-SPOTTED BEAN WEEVIL.

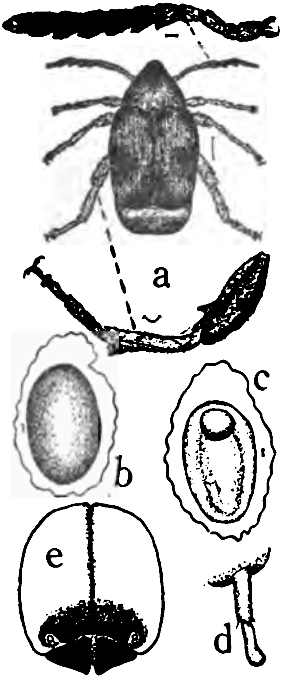

Fig. 9.—*Bruchus quadrimaculatus*, Fabr.: a, adult; b and c, egg from above and below; e, head of mature larva, front view. All enlarged.

The four-spotted bean weevil is a common and abundant pest in many parts of the Southern States, where it does much damage. It is an abundant pest in Florida in many different localities. See fig. 9.

LIFE HISTORY AND HABITS.

The eggs, when deposited on dried cow-peas, are placed on the outside, being firmly glued on by a thin cementing substance, which extends around them somewhat. The small oval eggs may be detected by the unaided eye. Larvæ, after hatching, bore into the peas, and begin to feed and grow. The pupal state is passed within the pea, and from which the adult emerges and deposits eggs for the next brood.

THE PEA WEEVIL.

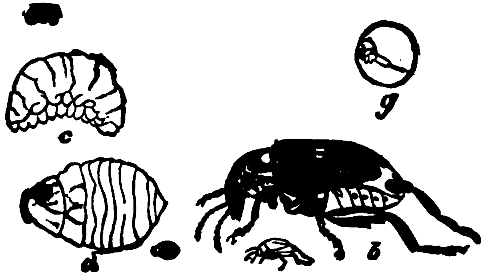

Fig. 10.—*Bruchus pisi*, Linn.: b, adult; c, full grown larva; d, pupa; g, pea showing exit hole. All enlarged except g.

This small beetle is quite familiar to all as the "pea-bug," and will be recognized as the pea weevil, from the accompanying figure. Originally confined to America, it has now become quite well distributed to most parts of the world.

The garden pea, which fortunately has not many insect enemies, probably suffers more from this insect than from any other. Its ravages on peas gathered for seed or other purposes however, may fortunately be prevented.

DESCRIPTION.

The *adult*, shown in fig. 10, is a small beetle, about one-fifth of an inch long, rusty black in color, marked with more or less white on the elytra, or wing-covers, and with a whitish spot on the caudal margin of the prothorax.

The *larva* is a short fleshy grub of a yellowish color, with the head black. See fig. 10, c.

The *eggs* are very small, of a deep yellow color, pointed on one end, and quite blunt on the other.

The *pupa* is shown at fig. 10, d. Fig. 11, a, illustrates the egg in its natural position on the pod and the outline of tunnel to b; c, is a young larva entering the interior of a pea; e, first larva, greatly enlarged.

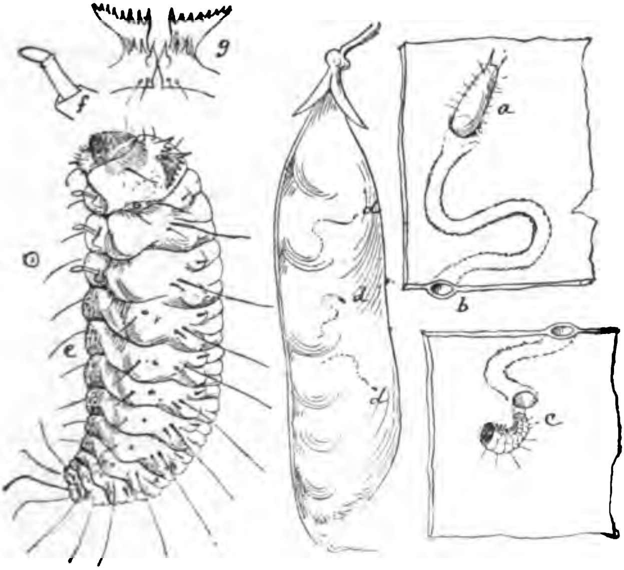

Fig. 11.—*Bruchus pisi*: a, egg in natural position on pod; c, young larva entering pea; d, points where eggs have been laid on pod; e, first larva.

LIFE HISTORY AND HABITS.

The eggs are deposited by the adult female, indiscriminately on the young pods, soon after they have begun to form. The larvæ, hatching eat to the interior and enter the soft peas within, only one grub occupying one pea. The embryo of the pea is rarely destroyed by the grub, but the plant resulting from its germination will be feeble, and dwarfed.

When the larvæ attain their growth and are ready for transformation, they eat a round hole outward to the shell of the pea, to allow for their exit as adults, and then pass into the pupa state. Adults may emerge in the fall, or in the spring.

The result of using weevily peas for seed should be noted. Weevily peas as before stated are not able to produce strong, healthy vines from the fact that the stored up nourishment for the plantlet in its early growth has been destroyed, and it is hence unable to get a strong vigorous start in the soil. It is quite important therefore, that peas selected for seed should be free from weevils.

THE SLENDER-HORNED FLOUR BEETLE.

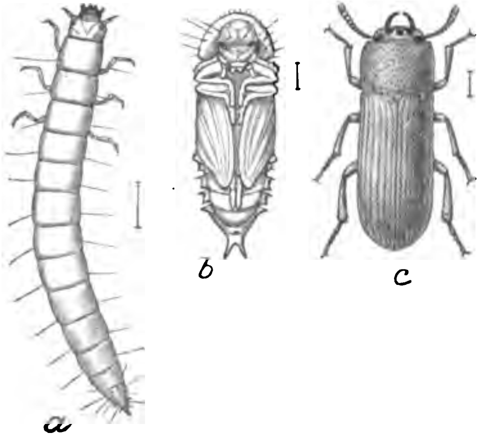

Fig. 12.—*Echocerus maxillosus*, Fab.: a, larva ; b, pupa ; c, adult; length indicated by hair lines.

The slender-horned flour beetle is quite generally distributed over the Southern States where it is destructive, feeding upon grain, both in field and when gathered. It is also destructive to cereal products. This insect is doubtless indigenous to tropical America. Its northern limit is probably in the region of the Ohio River.

DESCRIPTION.

The beetle is a small insect, a little more than one-eighth of a inch in length, bearing much resemblance to the species of *Tribolium* (fig. 13, a,) except that it is somewhat smaller, and lighter in color. On the head are two pointed protuberences. See fig. 12, c.

The *larva* is also much like the larva of *Tribolium.* The habits are essentially the same. It is illustrated enlarged at fig. 12, a. Fig. 12, b, is an enlarged drawing of the *pupa.*

LIFE HISTORY AND HABITS.

The habits and life history of this insect is for all practical purposes the same as those of the confused flour beetle.

THE CONFUSED FLOUR BEETLE.

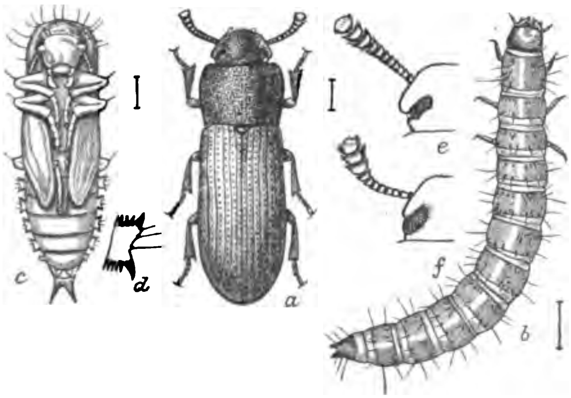

Fig. 13.—*Tribolium confusum*, Duv.: a, adult ; b, larva ; c, pupa; enlarged.

The confused flour beetle probably does not occur to great extent in this State. It is probable, however, that before long it will be found among us in injurious numbers and hence is here considered.

DESCRIPTION.

By a study of fig. 13, a, an idea of the *adult* may be obtained. It is a minute, elongated, reddish colored beetle of the length shown by the hair line at the right of the figure.

The *larva* and *pupa* are illustrated at fig. 13, b, and c, respectively.

LIFE HISTORY AND HABITS.

Eggs are laid in flour or other material infested, which hatch into small inconspicuous larvæ. In the due course of time the adults appear and eggs for another brood are laid. These insects increase with considerable rapidity, and soon bring about a loss to the infested substances. They impart to the infested material a persistent and disagreeable odor.

THE RUST-RED FLOUR BEETLE.

(*Tribolium ferrugineum*, Fabr.)

This insect is well known in Europe as a grain and flour pest. Dr. Hagen records it as also quite injurious to the collection of insects in the Museum at Cambridge. In the United States it seems not to have attracted much attention by entomological writers until the last few years. It seems now to be on the increase, and has already become a pest of no little significance. In Florida this insect is quite abundant, doing much damage to all forms of cereal produce, corn, cotton-seed, peanuts, dried fruits, and like substances. It is by far the worst museum pest with which we have to deal here at the Station. It attacks the herbarium specimens, bird-skins, and insect collection. To the latter it does most damage; presence in the specimens is indicated by the accumulation of dust beneath, on the bottom of the box. If an infested specimen be examined it will be found to be perforated with small holes which these pests have made. They feed upon the dried tissues within where their larval and pupal stages are passed.

Unless an insect case is exceedingly tight they find their way inside, their flat bodies enabling them to pass through very small cracks. Frequent inspections of the collections, and fumigation with carbon bi-sulphide is the means employed in keeping them in check.

DESCRIPTION.

The *adult* is a small beetle of a rust-red color, being a little more than an eighth of an inch in length. The body is greatly flattened, and is elongated. The insect bears a close resemblance to *Tribolium confusum*, but it differs from it in that in this species the antennæ end in a distinct club composed of three segments—(see fig. 13, e, and f.)

The *larva* is about one-fourth of an inch in length, and is quite active. It is of a whitish color, provided with three pairs of legs, and with numerous hair-like bristles distributed over the body.

LIFE HISTORY AND HABITS.

Eggs are deposited by the adult females, in the food upon which they feed. These hatch into minute, pale colored larvæ which when in flour, meal, and similar products, are rarely detected on account of their small size. These grow into full-sized larvæ which pupate and give origin to the adult beetles. The entire life cycle requires probably from thirty-five to forty days. In this climate it is quite probable that they breed throughout the year. This insect will attack corn while yet in the field, doing damage before the corn becomes hard.

THE RED GRAIN BEETLE.

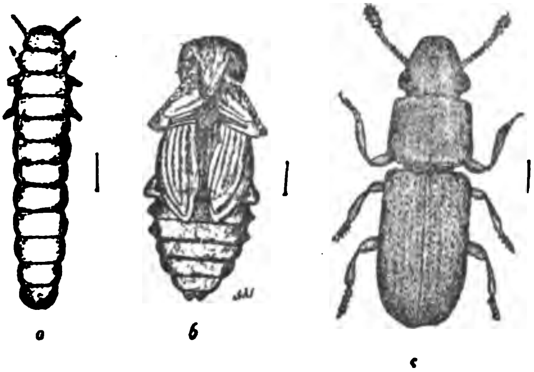

Fig. 15.—*Cathartus gemellatus*, Duv.: a, larva; b, pupa; c, adult; all enlarged.

This small red beetle is a pest of considerable importance in the Southern States. It attacks corn, peas, and the cotton-bolls of the cotton-plant in the field, and will continue breeding in corn after it has been gathered. Specimens of this insect were also found infesting bird-skins in the college collection.

DESCRIPTION.

The *adult* is a small, flat, reddish beetle, measuring one-tenth of an inch in length. In figure 15, c, it is illustrated much enlarged. The hair-line to the right indicates the natural length.

The *larva* when full grown is about the same length as the adult. It has a somewhat flattened body, of a whitish yellow color, with the head brownish. See fig. 15, a.

LIFE HISTORY AND HABITS.

The eggs, which are laid at the base of the grains of corn, soon hatch into small larvæ which at once eat into the grain. In the course of three weeks the larvæ become full grown, and transform into pupæ. This state last about two weeks, when the adults appear. These insects are very prolific and in infested corn stored away in the fall, they soon become quite numerous. It is probable that eight or ten generations are reared annually, and in some portions of Florida breeding is probably continuous.

THE CORN SILVANUS.

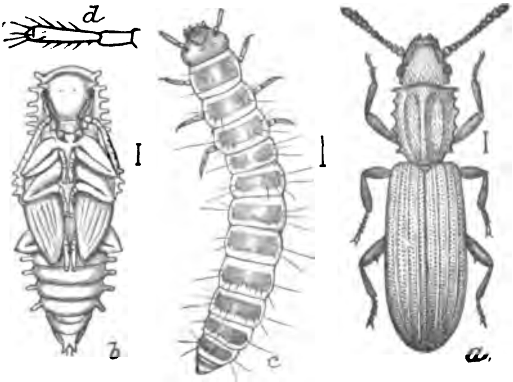

Fig. 16.—*Silvanus surinamensis*, Linn.: a, adult; b, pupa; c, larva.

The saw-toothed grain beetle is a small insect of the family *Cucujidae*. The majority of the insects of this family live under bark and are carnivorous, both in the larval and adult stages. The corn Silvanus, and some others of this family, however, feed upon grain. The corn silvanus is to be found over almost the entire globe, infesting granaries, barns, dwelling houses, grocery stores, and in fact almost any place where it may find food. In Florida it is very common in flour, meal, corn, dried fruits, rice, and bread. It is a common pest in the museum specimens here at the Station, and with the rust-red flour beetle is responsible for much of the damage done to the entomological collection.

DESCRIPTION.

The *adult* Silvanus is only about one-tenth of an inch in length, with a slender, much flattened body of a chocolate brown color. The thorax on each side is provided with six teeth-like projections, while the upper surface has two shallow longitudinal grooves. Fig. 16, a., represents the beetle greatly enlarged. The hair lines to the right represent the natural length.

The *larva*, represented in fig. 16, c, is a yellowish white, worm-like insect about one-fourth of an inch in length, provided with three pairs of well developed legs. It is exceedingly active, readily passing from one seed to another for food.

The *pupa* is illustrated in fig. 16, b, much enlarged. It is a little shorter than the beetle, of a yellowish white color, and has spinous processes on both sides of the thorax and abdomen.

LIFE HISTORY AND HABITS.

The life cycle in this climate requires about four weeks; it is thus readily seen that there may be many generations during the year. The eggs deposited among the grain soon hatch and the active larvæ begin to feed. When ready to pupate the larva constructs a protecting case by jointing together bits of trash and food material with a silken secretion. In this case the pupal state is passed, and from which the adult beetle emerges later on.

Unlike the Angumois grain moth the adult of this insect feeds upon the grain with the larva.

THE GRAIN-EATING BRACHYTARSUS.

(*Brachytarsus alternatus*, Say.)

This is an insect that has not heretofore been recorded as injurious to stored grain. The larvæ of the genus *Brachytarsus* have been supposed to be parasitic on scale insects, or Coccids, but this species has been found feeding, both in the larval and adult condition, on stored corn, cow-peas and English peas, and doing serious damage. The English name of grain-eating Brachytarsus has, therefore, been given to this species, indicating its grain-eating habits.

Many of the species of the family *Anthribidæ*, to which this insect belongs, infest seeds, and the stems of plants, in their larval state ; it is not the cause of much surprise, therefore, to find this species of snout beetle feeding upon various seeds.

DESCRIPTION.

The *adult* is quite a thick bodied insect of an ashy brown color, and densely hairy. The wing-covers are marked with punctured lines, and a series of gray and black spots. These spots are due to the presence or absence of the light colored hairs. It is about one-fifth of an inch long.

The *pupa* is about five thirty-seconds of an inch in length, whitish, and densely covered with short spine like protuberances. Rather long hairs are sparsely distributed over the body. The head is bent down on the ventral surface of the prothorax. Each wing-cover is marked with two pairs of rather prominent lines, the lines of each pair curving in and meeting each other at the distal extremity of the wing-cover.

The *larva* measures about three-sixteenths of an inch in length, is whitish in color, and footless. The body is quite robust, sub-cylindrical in shape, somewhat flattened on the ventral surface. The caudal end is rather bluntly rounded, the cephalic end tapering slightly from about the third segment. Labrum and mandibles yellow, the tips of the mandibles being almost black. The body is quite thickly covered with hairs.

LIFE HISTORY AND HABITS.

A single larva only occupies the interior of a kernel of corn, eating out a broad cavity from the base to the opposite end of the kernel, where it is usually enlarged, and a small portion eaten out to the hull before pupating. It would seem that the larva enters the kernel at its base where it may be more easily penetrated. An infested grain usually appears quite sound exteriorly until the pupal stage is reached when the cavity may be detected through the thin hull. The adult escapes by gnawing through the thin membrane to the exterior. Immediately after coming from the pupa state the adults are reddish brown, not acquiring their final color and activity for two or three days. Older specimens liberated from their cavities immediately took flight; they are surprisingly quick in the use of their wings, and thus frequently escape.

Adults kept in confinement fed readily on cow-peas and corn, showing no preference to any part of the seed.

Eggs have not as yet been discovered, nor has the manner of ovoposition been observed. Experiments indicate that under favorable conditions the life cycle may be completed in five or six weeks. Breeding continues as late as November and probably throughout the winter.

THE CATORAMA FLOUR BEETLE.

(*Catorama punctulata*, Lec.)

This small beetle, which may be called the Catorama flour beetle, is an insect of considerable abundance in corn, corn-meal, and flour. It is also quite destructive to museum specimens, particularly bird-skins and insects. It belongs to the *Ptinidæ*, a family of small beetles, which feed mostly upon vegetable matter in an incipient stage of decay.

DESCRIPTION.

The beetle is about one-eighth of an inch long, body rather elongate, the head being strongly deflexed, and when in repose bent up on the under surface of the prothorax. The beetle is of a dark brown color, quite densely and uniformly covered with light yellowish colored hairs.

TREATMENT.

Many different substances have been recommended at various times for the destruction of insects injurious to stored grain. Some of these are of value in a greater or less degree. Others are quite worthless. Certain preventive measures that are in practice in the South seem to be of some value. Most farmers in Florida do not husk their corn when harvested as the husks offer considerable protection against lepidopterous insects, and weevils. It is also a common practice to gather the corn and leave it in heaps in the field for a few days to allow the ants to destroy the larvæ that infest it. Others leave an open space in the roof of the crib so that rain may enter and thoroughly wet the corn, bringing about a period of heat that is said to destroy the infesting weevils and larvæ, doing no harm to the corn. It is a rather prevalent idea that certain varieties of grain are weevil proof, and inquiry is sometimes made for definite information on this subject. It should be known that there is no variety of grain that is weevil proof. However, the condition in which the grain is kept is of some importance. In general, unhusked grain is much freer from attack than grain that has been husked. Corn is much more subject to attack when shelled than when left on the cob. Those varieties of corn that have hard, flinty kernels and close fitting husks are not so subject to attack as other varieties. But it is hardly profitable to discuss these various preventive measures as we have in carbon bi-sulphide, a remedy that is effective, cheap, and simple in its application. Carbon-bi-sulphide was first recommended for use against insects, on a large scale, by Dr. Riley in 1879. Its use is yearly becoming much more general. Carbon bi-sulphide is a chemical compound of the formula $C S_2$; as the name and symbol indicate, it is a bisulphide of carbon. It is a colorless liquid, having a very strong, disagreeable odor, and is quite volatile, vaporizing at an ordinary temperature. It is also highly inflamable, and hence in its use care should always be taken that no fire of any kind be brought near it. A lighted match, lighted pipe or lighted cigar should not, under any circumstances, be brought near a building that is being fumigated. The fumes of this compound are very poisonous. Therein lies its value as a destructive agent against insects. The deadly fumes of this compound enters their breathing tubes with the air which they breathe and quickly brings about their death. The fumes are also poisonous to other animals, but there is little danger to man from inhaling a small quantity.

DIRECTIONS FOR USE.

The application of carbon bi-sulphide is but a process of fumigation, and in order that the fumes may be kept within the bin or crib they should be as tight as possible. If they are not tight much more of the compound will be required. Bins may be made much tighter by covering them as much as possible with cloths and blankets. Oil cloth and heavy canvas are excellent. In a moderately tight bin one pound of the sulphide should effectually fumigate one hundred bushels of grain. Several methods are in use for the application of the sulphide. A ball of cotton tied to a stick may be saturated with the compound and pushed down to near the center of the grain. By doing this, it is believed that the air becomes more evenly saturated with the sulphide. Another method consists in pushing a long pipe, in which is a tight fitting rod, down into the grain. The rod is withdrawn and the carbon bi-sulphide poured into the tube, and after which, it may be withdrawn. But the most effective way of applying the compound, when the bins are moderately tight, is to pour the reagent in shallow dishes or pans which may be placed here and there on the top of the grain. The compound being volatile rapidly vaporizes, and being heavier than air, sinks and becomes thoroughly diffused throughout the bin. Balls of cotton or waste may be saturated with the sulphide and distributed over the surface of the grain. In case all the insects are not destroyed by one application, another should be made. Grain treated with the sulphide is not injured for food purposes, or for seed. To secure the very best results from the use of carbon bi-sulphide a tight quarantine bin should be made, somewhat separated from the other buildings, where the grain may be subjected to a thorough fumigation before being stored away. Here the insects that have gotten into the grain while in the field will all be destroyed, thus removing a serious source of infection to the stored grain. Before a crib is to receive the harvested and fumigated grain, it should be thoroughly fumigated and cleaned. All cracks, loose fittings, and holes should be stopped up as well as possible.

Grain having been fumigated and placed in a tight crib or bin that has been cleaned will suffer but very little from the ravages of insects during the year. Should they become troublesome at any time another application of the sulphide should be made.

Peas, rice, shelled-corn and other seeds are frequently stored in barrels or boxes. These may be easily fumigated by saturating a piece of cotton with four or five ounces of carbon bi-sulphide and placing it on top of the seed, throwing a heavy cloth over the top of the barrel to keep the fumes within. It should be noted that the treatment given above, is for grain that has been husked or hulled. Where the grain is not husked a somewhat larger quantity of the bi-sulphide will be needed.

It is the prevailing custom in this State to harvest corn unhusked, on account of the protection afforded by the husks against weevils and moths. The husks, however, interfere with the best results that may be obtained from the use of carbon bi-sulphide, as the fumes do not so readily reach the insects.

The protection afforded by the husks against grain insects is far less than the advantages gained by having it husked so that it may be the more thoroughly subjected to the fumes of the insecticide. It is therefore recommended that corn be husked when harvested, and carbon bi-sulphide be used to keep it free from weevils and other insects.

Carbon bi-sulphide may be purchased at drug-stores for twenty to thirty cents per pound. It may be purchased at wholesale rates in fifty pound cans of Mr. Edward R. Taylor, Chemist, Cleveland, Ohio, at about ten cents per pound. Arrangements might be made with local druggists, who would order carbon bi-sulphide in fifty pound cans, or larger lots, and who could then afford to sell it much cheaper than the usual retail price.

ACKNOWLEDGMENTS.

I desire to express my thanks to the United States Department of Agriculture, through Mr. L. O. Howard, United States Entomologist for the use of figures 1-7, 10-13, and 16; to Prof. Slingerland, of Cornell University, for the use of figure 9; to Prof. H. E. Weed, of the Mississippi Station for figure 15.

Dr. E. A. Swartz, and Mr. F. H. Chittenden, of the Division of Entomology at Washington, have kindly determined some of the beetles herein considered for me. Prof. Rolfs has kindly looked over my manuscript.

Bulletin No. 37. November, 1896.

FLORIDA
Agricultural Experiment
STATION.

The Pineapple at Myers.

BY

O. CLUTE AND W. A. MARSH.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

DELAND, FLA.
THE FLORIDA AGRICULTURIST,
1897.

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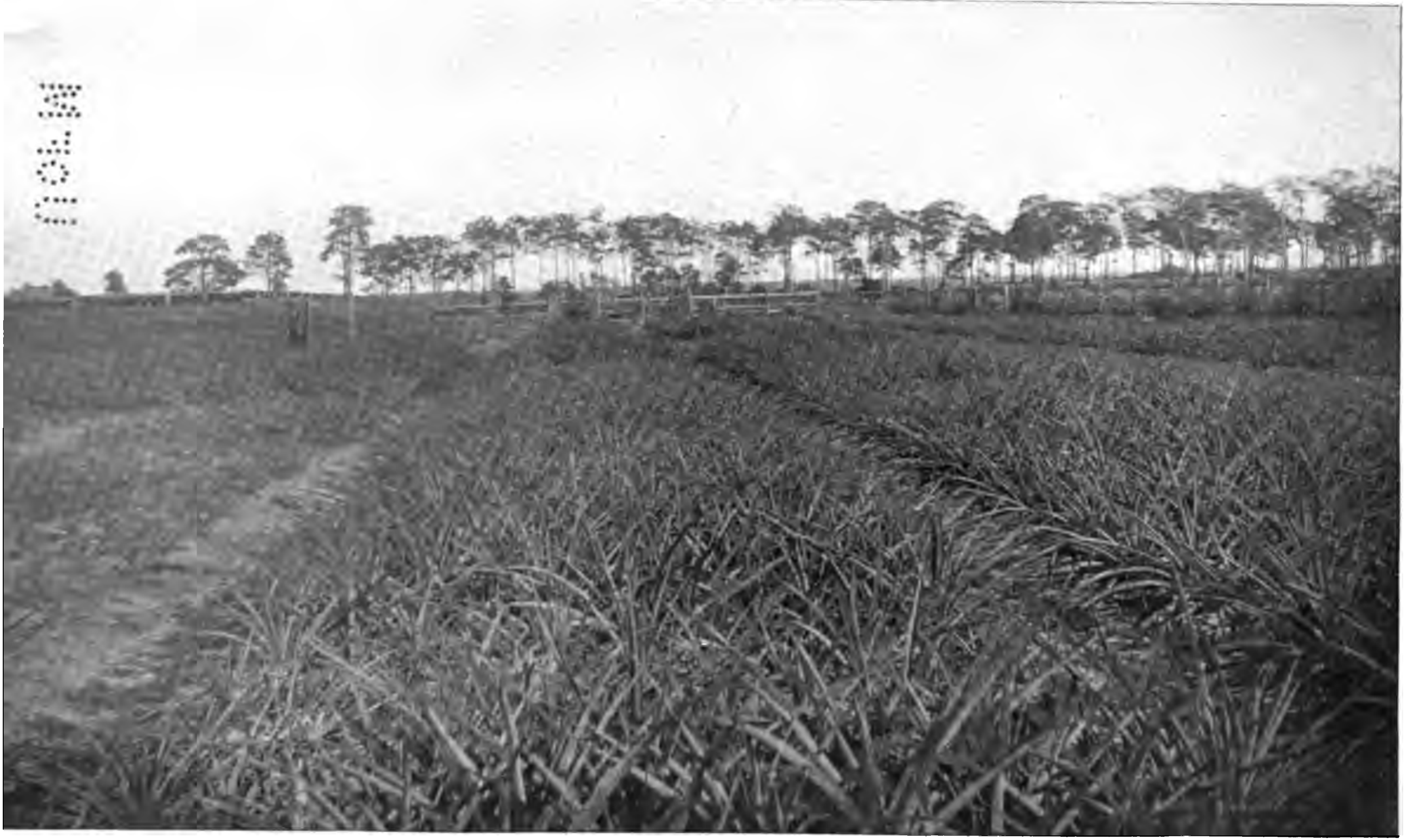


PINEAPPLES IN THE OPEN FIELD.

THE PINEAPPLE AT MYERS.

SOIL.

The soil on which the pineapple is grown at this station is as poor as any in the state. It is almost entirely destitute of the elements of fertility, being about 95 per cent. sand. It is underlaidwith hard-pan at a varying depth of from eighteen inches to two and one-half feet. The top soil is a dark grey sand, from two to four inches deep; between this and the hard-pan it is white sand. The hard-pan varies in thickness from four to eighteen inches. Immediately under the hard-pan is a permanent water sheet. The native growths on this land are pines of medium size, short bodied, about twenty-five to the acre; the under growth is scrub palmetto, known in some sections as "hog palmetto."

PREPARATION OF SOIL.

The soil is all cleared of trees, stumps, and roots, plowed and cross-plowed deeply until it is entirely free from roots, and in perfect condition. Now spread broadcast over the land 1,000 pounds per acre of cotton seed meal, or better, blood and bone, and plow under shallow. Let the land lie three weeks and them plow into beds, running the plow as deep as possible. Make the beds ten feet wide and the paths five feet. These paths really constitute broad shallow ditches, so that the water may be carried off immediately into large deep ditches, and so prevent the beds from remaining too wet after heavy rains. The main ditches at this station are three feet deep, three feet at the top, one foot at bottom and twenty rods apart. We shall hereafter make them closer together.

PREPARATION OF PLANTS.

In preparing the plants for setting a few of the leaf scales at the lower end of the plant should be pulled off. Embryo roots will be seen on the main stalk where these scales were growing. Care should be taken not to pull off too many of the scales so that they break into the tender portion of the plant.

Nothing is gained by cutting the butt ends of the plants. I have taken up a great many plants and have never seen one with roots coming from the cut ends. The plants are now ready for setting.

SETTING.

Stretch lines lengthwise of the beds 10 feet apart. Walk the line. It may be then taken up, and will leave a plain groove the length of the bed. This gives the outside row. Then take strips one inch by three inches wide, with the distances between the rows marked on them. These strips should be about twenty feet long. Lay one on each side of the bed just outside the line. Now take a board ten inches wide and ten feet long, with the distances between the plants in the row marked on it. This is used to lay across the beds when setting plants so that the beds may not become trodden down.

The plants should be set only deep enough to secure firmness,—from one and one-half inches to four inches, according to the size of plants. As to distances the following are the best and give nearly equal results: 18x30, 20x30, 15x36, 18x36. These distances give ample room for fertilizing and cultivation, and are almost equivalent to two feet each way. It will take about 9,000 plants to the acre. Large plants are to be preferred; they are less liable to become sanded, start vigorously, and often produce good fruit in from ten to fourteen months. Twelve to twenty-four inch plants may be considered most desirable, but smaller plants may be depended on to produce a good crop the second year. We do not find that the fact of a plant being crown, crownlet, slip, sucker or ratoon makes any difference as to time of fruiting, but plants of a given size will fruit in about the same number of months from setting.

CULTIVATION.

The soil should be kept well stirred and free from weeds. After the plants are set no tool except the scuffle hoe should be used. One of triangular shape is best, the shank being set in the center, as it leaves the points free so that the spaces between the plants may be worked with ease. The hoe should be run shallow, not over an inch deep in the middle of the spaces, and only skimming the surface near the plants. The roots of the pineapple are almost immediately under the surface.

FERTILIZING.

At this station the greatest success has been secured by fertilizing often, say once in two months, using 1,000 pounds per acre at each application. This method will require three tons per acre each year, and gives best results on this class of land. The cost is about one cent per plant for the year. We find the following fertilizing materials well suited to the growth of the pineapple: Of commercial materials, blood and bone, ground tobacco, sulphate of potash (high grade) and nitrate of soda combined in proportions to give a manure containing six to 7 per cent ammonia, 7 to 8 phosphoric acid, and 8 to 10 of potash. Any person may readily purchase the materials in all portions of the state. The following mixture will be found to contain the ingredients in about the proper proportions: 1,000 pounds blood and bone, 600 pounds ground tobacco stems, 200 pounds nitrate of soda, 200 pounds sulphate of potash, 90 to 95 per cent. The materials should be placed on a tight floor and shoveled over and over until they are thoroughly mixed.

APPLYING FERTILIZERS.

In fertilizing throw the fertilizer in from each side of the bed. With a little practice it can be done with the largest plants so that very little will fall into the buds or into axils of the leaves. Where fertilizers are allowed to fall into the plant holes are burned in the leaves, and the heart of the plant often is burned out. Never put cotton seed meal into the bud of a pineapple plant. It is very apt to burn out the heart, and so set the plant back several months, for the plant must throw a sucker before it can fruit. Of domestic materials fine well-rotted stable manure or fowl house manure spread on the surface and gradually worked into the soil will be found to produce a vigorous plant growth, but should not be depended on entirely, as fruit so grown will not ship well, and is liable to be too acid. Ground tobacco may be sown thinly and evenly over the plants. The small amount that would fall into the bud will not ferment to any considerable extent, and it acts as an insecticide. The ertilizer should be worked into the soil with the scuffle hoe, nning over the ground the same as in ordinary cultivation. e have not found that the use of acid phosphate, when used to limited extent in connection with other manures, was attended ith any evil results. But would not recommend that it be de-
nded upon entirely as a source of phosphoric acid.

INSECTS AND DISEASES.

The only insects that have appeared on the plants at this station are the mealy-bug and chaff-scale, and they can be kept in check by spraying with a strong solution of tobacco, or with sulphur solution. Use 1½ gallons of sulphur solution to 20 gallons water. Ground tobacco may be sown lightly broadcast over the plants and is a good preventive, also acting as a fertilizer. In checking insects and diseases on pineapples, as with all other plants, more than half the battle is in keeping the plants vigorous.

BLIGHT OR TANGLE ROOT.

Of diseases we have been troubled to some extent by what is termed "blight." The symptoms of the disease consist in the drying or shrivelling and turning yellow of the leaves, commencing at the tips and gradually extending over the whole plant. On examination the plant may be found to be rotting at the base, or the plant may not have rooted and on pulling down the lower leaves the roots will be found to have run around and around the body of the plant under the leaves, hence this disease is termed by some "tangle root." We think blight and tangle root are identical. When plants are seen to be affected it is a good plan to pull off some of the lowest leaves. This can be done readily by giving a little twitch sidewise. If the plants show further advance of the disease they should be taken up, trimmed and re-set. They will often recover. Spraying with sulphur solution seemed to check the disease here. The cause of the trouble has not been fully determined. The only varieties affected at this station were Golden Queen and Smooth Cayenne.

LONG LEAF.

"Long-leaf," may be recognized easily. It consists in the leaves of the plant becoming contracted and making a very slow growth, and is evidently due to some untoward condition in the soil. The affected plants at the station, were in little hollows where, after a heavy rain, water stood for some time. On moving the plants to higher ground many of them developed into healthy plants. All plants so affected were found to be very deeply set. The conclusions drawn are that by perfect drainage and by avoiding very deep setting the trouble may be obviated.

Care should be taken in using flour of sulphur on pineapple plants, especially in the soil. A teaspoonful put immediately under and around a plant at time of setting will rot the plant as surely as it is put there. Avoid also the application of burned lime in any considerable quantities, as the plants do not take kindly to it.

VARIETIES.

Red Spanish or Scarlet. Flesh white, rather fibrous and tart; weight 1½ to five pounds; flavor good; shape shouldered; good shipper; grown in greater numbers than any other variety probably because the plants can be easily procured. Considered by some the best all-around pine. Fairly prolific in slips and suckers.

Sugar Loaf. Flesh white, very sweet and tender; fine table fruit; poor shipper; shape conical; weight 1½ to four pounds; smooth. Sells well in local market. Fruit often rots on the plant before fully ripe. Prolific in slips but not in suckers.

Black Jamaica. Flesh white, very tender and juicy, finest flavor, weight two to six pounds; shape columnar; very smooth; good shipper. Prolific in slips and suckers.

Prickly Cayenne. Flesh yellow, tender, good flavor; shape shouldered and conical; fruit sometimes larger at apex than at stem end; good shipper; smooth; weight three to six pounds. Prolific in slips and suckers. Plant broad leaved and vigorous.

Smooth Cayenne. Flesh yellow, tender; flavor fine, very juicy; shape shouldered; very smooth; good shipper; weight three to nine pounds. Prolific in suckers, but not in slips; we only had two slips from 100 plants. This no doubt is the most popular variety grown, owing to the fine appearance of its fruit, and the smoothness of its foliage, making the plants very pleasant to work among. The leaves of all other varieties are very spiny on the edges.

Enville, or Enville City. Flesh white, tender, juicy; flavor ood; shape conical, flattened at apex; multiple crown; rough; ood shipper; weight, three to ten pounds. Prolific in crownets, slips, and suckers. The misshapen fruits, and the tendency o rot before fully ripe, form an objection with many. A numer of specimens will be seen with single crowns, and the fruit of symmetrical form, and this tendency may become a fixed characteristic by selection, and so render the variety more valuable. The tendency of the fruit to rot before reaching full maturity, may be overcome to some extent by judicious manuring, avoiding the application of highly nitrogenous manures during fruiting season.

Abbaka. Flesh yellow, tender, very juicy, fine flavor; shape, shouldered; smooth; good shipper; weight three to ten pounds; prolific in slips and crownlets, but few suckers. This variety will yield a greater increase of plants than any of the plants grown at this station. Some of our Abbakas yielded this season as high as thirty plants; they averaged twelve plants apiece. A popular variety.

Golden Queen. Flesh yellow, very tender and juicy; flavor good; shape columnar; good shipper; rough. A favorite with many. Prolific in both slips and suckers.

Prince Albert. Flesh light yellow, tender and juicy; flavor fair; weight two to six pounds; rough. Prolific in slips and suckers.

Porto Rico. Flesh light yellow, tender and juicy; flavor good; shape shouldered; good shipper; weight four to fifteen pounds; smooth. This variety is immensely popular on the East coast.

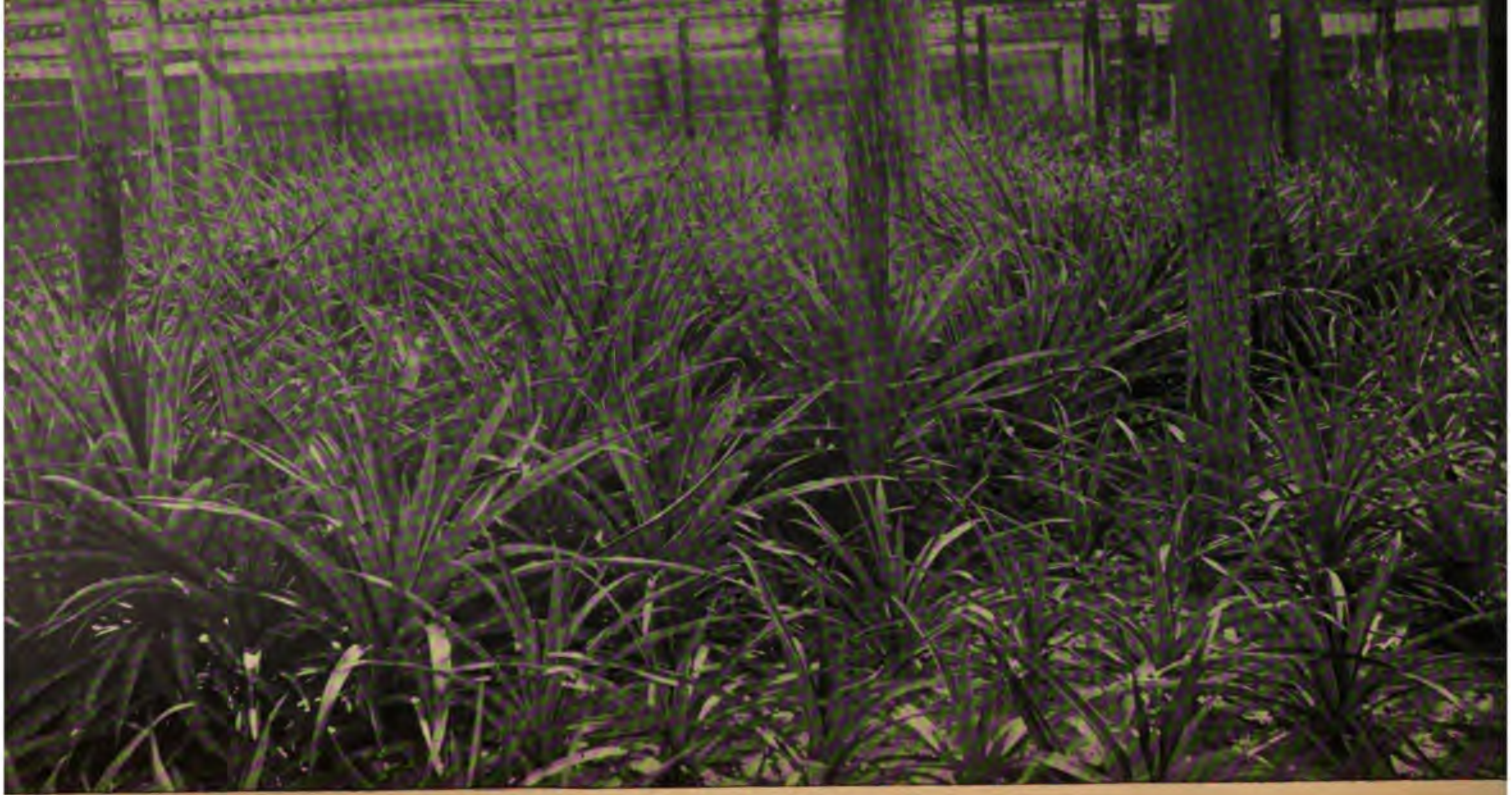
COMPARATIVE VALUE OF VARIETIES.

Experience at this station indicates that varieties of pines are valuable in the following order: Smooth Cayenne, Abbaka, Golden Queen, Enville City, Porto Rico, Black Jamaica, Prickly Cayenne, Red Spanish, Sugar Loaf.

KEEPING QUALITIES.

A partial test was made in July to determine the keeping qualities of different varieties. Too much dependence must not be placed on this test, as only one specimen of a variety was used. July 18th, 1896, one each of the following varieites were picked at the proper stage for shipping, wrapped in paper, packed in a crate and placed in a room of even temperature: Red Spanish, Black Jamaica, Enville City, Smooth Cayenne, Abbaka, and Golden Queen. August 3rd, the fruit was examined. Enville City was unmarketable; Abbaka, Smooth Cay-

UofM



PINEAPPLES UNDER SHELTER.

enne, Golden Queen and Red Spanish commencing to spot; Black Jamaica in perfect condition. August 7th, Red Spanish and Golden Queen unmarketable. August 11th, Smooth Cayenne and Abbaka unmarketable, Black Jamaica still in good condition. August 16th Black Jamaica softening and turning brown, but on cutting was found to be in good eating condition. This partial test gives the Black Jamaica the palm for keeping qualities.

PINES UNDER SHELTER.

The advantages of culture under shelter over the open field are numerous. The shelter produces more nearly the natural conditions under which pines grow, giving the shade of the forest without having the roots to contend with, there is less waste of manure, moisture is preserved; plants are more vigorous and the fruit is superior in appearance and quality; the plants are protected from heavy and cold winds, frost, and too great heat of the sun. These are some of the advantages of the shed over the open field. The cost of covering land is from $300 to $500 per acre, according to location and cost of material.

The following directions show one way to build a pine shed: The posts should be eight feet long and not less than four incres in diameter at the top.

The lumber for the sides should be ¾x10 inches x15 feet.

The lumber for the top should be ⅝x3 inches x16 feet.

The lumber for the stringers should be 2x6 inches x 16 feet.

The posts in the outside wall should be set 7½ feet apart. The posts inside should be set, first row from the outside, commencing always to stake at the same side, 15 feet apart; next row set first post 7½ feet from outside afterwards 15 feet apart; third row 15 feet apart; fourth row 7½ feet from outside for first post; and so on through the whole area to be covered. The posts should be set 18 inches in the ground, 6½ feet from surface to top. The stringers are 16 feet long, and are set on edge on top of the posts, they will lap a little and should be spiked to the post and to each other with 20 penny spikes. The sides should be nailed on horizontally, thus saving a great deal of sawing, and extra lumber for stringers that will be needed if the lumber is put on vertically. The slats for the top should be lapped over each other at the ends and the nails driven through both at once. If the slats are put three inches apart half the space is covered. Some cover three-fifths of the space, leaving only a two inch space between the slats.

Material needed to cover 210 feet square or one acre, will be about as follows:

433 posts, at 10 cents		$ 43.30
364 stringers, 2x6 inches x 16 feet	5824 feet	
Slats for top, 1x3 inches x 16 feet	22050 feet	
Plank for sides 1x12 in x 16 ft	5460 feet	
Total at $14 per M.	33334	466.68
		509.98
Cost of erecting		20.00
		$529.98

This is about what it would cost to shelter one acre at Myers, with present cost of labor and lumber. In covering large areas the cost per acre would be somewhat less.

OPEN FIELD CULTURE AND SHELTERED CULTURE.

In October, 1894, some experiments were commenced to determine whether the cultivation of the pineapple was more profitable under shed or in open field. A shed covering one-tenth acre was erected, and in it were set 826 plants of the following varieties: Abbaka, 99; Prince Albert, 33; Black Jamaica, 22; Golden Queen, 99; Prickley Cayenne, 33; Sugar Loaf, 88; Enville City, 88; Smooth Cayenne, 99; Red Spanish, 11; Queen, 254. The plants did not quite fill the one-tenth of an acre. Previous to setting the soil was fertilized with 100 wheel barrow loads of scrapings of hen yard and horse barn, of which the greater part was sand of little value; 400 pounds cotton seed meal, and 50 pounds sulphate potash, high grade. The plants were not injured by the freezes of December and February 1894 nd 1895, and in the summer of 1895, 45 apples were produced. After setting no fertilizer was applied until July 30th, 1895. From this date on, the plants were fertilized every two months, at the rate of 1,000 pounds per acre.

Some of Wilson & Toomer's pineapple manure was used with good effect; also cotton seed meal, acid phosphate, and sulphate potash 90 per cent, blood and bone and potash were used. The best results were obtained with blood and bone and potash, and Wilson & Toomer's pineapple manure. The experiments with the mixture now being used, given in foregoing pages, is giving very satisfactory results so far as tried.

In the spring of 1896 the plants under shelter bloomed well, but drouth in April and May, and very heavy rains in June caused a shrinkage in the size of the fruit. Pines to the number of 618 were gathered from the shed. Plants to the number of 5,250 were obtained from the shed, besides the original stand of plants. The value of the fruit, sold in the local market,

was	$ 99.42
Value of plants at present prices	416.60
	516.02
Cost of labor and fertilizer for one-tenth acre from time of setting to first crop	20.00
Net proceeds from 826 plants	$496.02

This large return from less than one-tenth of an acre is due to selling the fruit in local market, and so saving transportation and commission, and also largely to the value of the increase of plants. The varieties we had under shelter were fine ones. The demand for such plants has been brisk, and our increase of 5,250 plants would have brought a larger sum in cash than they are credited with above. We used the plants to increase our plantation.

That such returns can be counted on permanently and on a large scale no one will affirm, but a net return of from $300 to $500 per acre may be confidently expected on ordinary fruit, not including increase of plants, when grown under cover; and on the finer varieties much more.

The plants in the open ground, set at the same time in the fall of 1894 as those in the shed, were all frozen to the ground in the freezes of December, 1894, and February, 1895. Not a fruit was obtained from them in 1895, while those in the shed gave 45 fine fruits in 1895. The pines in the open ground have been treated in all respects the same as those under the shelter. While from less than one-tenth of an acre under shelter there were obtained 618 pines, as above stated, from those grown in the open ground no fruit was obtained in 1896. The pines in the open ground were killed by the freezes of 1894 and 1895. They at once began to throw out suckers, which grew to fair sized plants during 1895, and continued growing very well in 1896, but did not reach sufficient size to fruit, while those in the shelter grew twice as fast as those in the open, and the fruit of all varieties we have grown under shelter is larger and in every way superior to that grown in the open field. Those outside have now a good general appearance, and the coming season, if it is a favorable one, will give a fair comparison of the two methods of cultivation as shown in the fruit and the increase of plants.

The cost of labor and fertilizer per year, in the open field, after the first crop, would be about $100 per acre.

The cost of labor and cultivation for pines under shelter is the same as for those in the open, after the shelter is paid for. If we charge one-fifth of the value of the shed to each year's crop for the first five years, we shall make the cost of shed, fertilizer, and labor for the sheltered pines $200 per acre per year. After the first five years, the shed now being paid for, the yearly cost of an equal area of pines under shed and pines in the open will be the same.

COST OF LAND AND OF PLANTS.

The average cost of land in thorough condition for setting is not far from $60.00 per acre. This includes the first cost of land, and the cost of clearing. The cost for work and fertilizer to carry the plants to first crop is about $200 per acre. The average cost of the different varieties of plants is as follows: Smooth Cayenne, $150 per M; Abbaka, $100 per M; Porto Rico, $100 per M; Golden Queen, $75 per M; Black Jamaica, $200 per M; Prince Albert, $100 per M; Enville City, $250 per M; Sugar Loaf, $25 per M; Red Spanish, $8 per M. This list includes only those varieties that are generally cultivated, and the cost of plants may vary in some localities somewhat from the prices given here.

Wild land in the vicinity of Myers can be bought at prices varying from $1.50 an acre to $20 an acre. So far as land goes the main cost of a pineapple plantation is in clearing, ditching, and the first plowings.

EXPLANATIONS OF TERMS.

In the descriptions of varieties the terms "rough" and "smooth" indicate the waste in peeling. "Rough" varieties are those that waste most in peeling.

A "sucker" is a young plant growing from a bud on the mother plant at or near the point where the mother plant emerges from the ground. In some varieties of pines a strong plant of a year old or more will produce several suckers. If a sucker is taken from the main plant and set out it soon grows into a new plant.

A "slip" is a small young pineapple bud or sprout, looking like a small pineapple plant, that grows at the base of a pineapple fruit. Some varieties of pines produce several slips at the base of every fruit.

The "crown" is the upper, growing, leafy end of a pineapple fruit. If cut from apple and planted, a crown produces another plant, just as a sucker, or a slip will. Sometimes the crown is divided into several small crowns, called "crownlets." A crownlet, if planted, produces another plant, but being small it takes probably two years for it to produce fruit. A large sucker will produce fruit in one year. The demand for plants is active, so that larger income is often received for plants than for fruit. This leads to cutting the crowns from pines before they are sent to market. To do this is no injury to the fruit, it saves much space in packing and hence in transportation, and it preserves the crown for planting.

A "sanded" plant is one in to the growing centre of which wind has blown so much sand as to interfere with its growth.

TEMPERATURE AT MYERS.

The lowest temperature for 1894 was 22 degrees on the 29th of December.

	Highest Temperature Degrees	Lowest Temperature Degrees	Mean Temperature Degrees
1895			
January	82	38	65
February	84	35	59½
March	87	44	61
April	88½	50	71¾
May	95	62	80¾
June	99	66	79
July	96½	73	82
August	95	74	81
September	92	69	80½
October	88	62	76
November	86	48	71
December	82	39	59¼
1896			
January	78	38½	61
February	83	36½	62½
March	89	43	68¼
April	90	54	74
May	94	63	79
June	95	71	81¼
July	94½	74	81¾
August	95	73	82¾
September	92	70	81¼
October	87	60	75¾
November	86	60	74¾
December	82	46	61½

1895 average highest 89 7-12, average lowest 55, average mean 72¼.

1896 average highest 88 10-12, average lowest, 57 5-12, average mean 73 7-12.

RAIN FALL.

The period of greatest rain fall is from June 1 to October

1. Often during this period the rains are excessive. During the remainder of the year rains are only moderate, and we have week after week of clear, sunny skies, with temperature as above indicated. The period of greatest drouth is during April and May. A drouth of more or less severity may be expected at this time each year. At this time some form of irrigation would prove of great advantage, for in April and May the fruit is in a critical condition, and if they have plenty of moisture at this time will make very much larger apples.

CONCLUSIONS.

1. Pineapples can be grown at a profit on the poorest soils of the west coast of Florida, if properly fertilized.

2. The fertilizer mixed by us and used with success on pines has contained the following: Six to seven per cent of ammonia, seven to eight per cent of phosphoric acid, and eight to ten per cent of potash. A mixture made up of 1,000 pounds blood and bone, 600 pounds ground tobacco stems, 200 pounds sulphate of potash 90 to 95 per cent, has given excellent results. Toomer & Wilson's, (Jacksonville, Fla.,) pineapple manure has given good results. In soils destitute of humus a generous dressing of well-rotted stable manure scattered broadcast and plowed in before setting the plants will be of great benefit.

200 lbs.
nitrat
of sod

3. Thorough drainage is essential to success. This drainage may be accomplished by open ditches, three feet deep, and ten rods apart, into which wide shallow ditches conduct the surface water. These wide shallow ditches may be the walks between the beds of pines.

4. The varieties in general cultivation as far as we have tested them are valuable in the following order: Smooth Cayenne, Abbaka, Golden Queen, Enville City, Porto Rico, Black Jamaica, Prickly Cayenne, Red Spanish, Sugar Loaf.

5. The ordinary pineapple shelter protects the pines against sun, wind, and cold, so that the plants fruit better, give larger fruit, the fruit is of better quality, and the increase of plants is greater than with pines cultivated in the open field.

6. To shelter pines costs from $300 to $500 per acre. The increased income from fruit and plants will more than pay for this increased expense.

7. In shipping long distances the keeping qualities of varieties are of great importance. A single test in the summer of 1896 showed the keeping qualities of the varieties tested to be in the following order: Black Jamaica, Smooth Cayenne, Abbaka, Red Spanish, Golden Queen, Enville City.

OPINIONS OF PROMINENT GROWERS.

Mr. Geo. I. Russell, Orlano, Fla., recommends broadcasting two tons of blood and bone to the acre before setting, plow deep and rake well. When plants are half grown apply one-half ton sulphate potash per acre. Cultivate shallow, using a scuffle hoe, always keep the land free from weeds and grass. Best varieties, Enville City, Abbaka, Smooth Cayenne, Golden Queen, Prince Albert. Best distance 18x30. To prevent disease spray with Bean's Insecticide, and sprinkle tobacco dust over plants. If land is very poor, plow in stable manure or composted muck.

Mr. John B. Beach, West Palm Beach, Fla., says from 22 to 24 inches is sufficient distance for ordinary pines; Porto Rico 30 to 34 inches. By close setting, plants give each other support, and shade the ground. Recommends cotton seed meal and tobacco for first year, the latter mainly for insecticide; second year, steamed bone and sulphate potash. After each crop stimulates with ammonia. Warns growers against acid phosphate and considers it poisonous to pines. Amount of fertilizer per acre from one to two tons . Most profitable variety, Porto Rico.

Mr. James Mott, Winter Haven, Fla., prefers pine land with yellow sub-soil, on which no crops have been grown. Considers shed grown pines in every way superior. Avoids tramping over the beds when setting, using a wide board to stand on. Before planting plows under one-half pound of blood and bone to the plant. When plowing breaks up subsoil with bull tongue following the turning plow. Second fertilizing uses one-half pound cut tobacco stems per plant; third, one-half pound blood and bone per plant; and fourth time one pound cut tobacco stems per plant; all this for one year. Best distance 18x30; beds nine feed wide; paths five feet. Considers Smooth Cayenne best pine. Abbaka, Porto Rico, and Golden Queen also good. For mealy bug uses bi-sulphide of soda, one-fourth pound to two gallons of water. Thorough fertilizing best preventive.

Mr. F. N. Price, Orlando, Fla., fertilizes land before setting, and puts the soil in as fine condition as possible; subsequent cultivation done entirely with scuffle hoe. Considers 18x30 proper distance. Is not troubled by disease. For mealy-bug sprinkles plants with sulphur. Fertilizes in spring with blood and bone, 1,600 to 2,000 pounds per acre; in fall with bone and potash. Best varieties Smooth Cayenne, Abbaka and Golden Queen.

Bulletin No. 38. January, 1897.

FLORIDA
Agricultural Experiment
STATION.

Tobacco in Florida

A Revision of Bulletin No. 30, with Additions.

BY

F. B. MOODIE.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

DELAND, FLA.
THE FLORIDA AGRICULTURIST,
1897.

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Tobacco in Florida.

MANUAL OF TOBACCO CULTURE.

I shall direct attention first, to the culture and treatment of cigar leaf, and then to the culture and treatment of the bright plug leaf, that being the only type of plug tobacco that it is advisable to plant in Florida.

SELECTION OF SEED.

I have experimented with over twenty varieties of cigar leaf and have rejected all but three or four, they proving the most profitable. If the object is to supply a wrapper and filler equal to the Havana the consensus of opinion is in favor of the Vuelta Abajo.

If the object is to grow a crop of wrapper tobacco, the poorer leaves of which make only an inferior grade of "binder" or "filler," genuine Sumatra seed is to be recommended.

After ten years searching, I have at last found the old celebrated ante bellum, Florida Speckled Wrapper, that was so eagerly sought for by the Amsterdam and Hamburg leaf dealers. But this variety must not be planted on any but new gray sandy loam hammock. It grows too heavy and coarse on old lands. It must be topped as high as possible, and cultivated very lightly, with hoes mostly.

The so-called Ma Nicaragua, or Moodie's Hybrid, which won both Medals at the Centennial in Cincinnati in '88, and twice at other fairs, and was pronounced by a committee of New

England Experts, as the "finest wrapper ever grown in the world," succeeds only in certain light hammock lands, when planted very early. It makes on old land a good filler.

HOW TO DISTINGUISH PERFECT FROM IMPERFECT SEED.

Put a few seed on a clean, hot tin or stove, when if the seed are dead they will quietly burn black; otherwise they will remonstrate, by an apparent endeavor to jump off. If, however, only a few complain of the intense heat, double the quantity to be sown on the bed. But better get fresh seed.

TIME TO SOW SEED.

In the northern counties of Florida sow the first beds of Vuelta Abajo from the 1st to the 15th of January; then sow one or more beds every week or two till the last of February, to insure a sufficiency for a large crop. It is not safe to rely on one seed-bed. Further south seed may be sown earlier, the object being to transplant just as soon as danger of late spring frosts is past, for tobacco, like tomatoes or other vegetables, should be in the field as soon as safe from frost. Sumatra seed should not be sown as early by three weeks,—it being a later variety.

LOCATION AND PREPARATION OF SEED-BEDS.

Select a rich, moist place, as near as possible to water, and if sloping to the south the better; not one much shaded—must have sunlight. On the nature of the seed-bed soil depends the nature and worth of the plant. It must be borne in mind that foliage and not fruit is the objective crop. If seed are sown on very light sandy loam, dry and thirsty, the roots will descend into the ground for moisture, and there will be no surface lateral rootlets, but only a long "tap-root" with very few branches. On such a plant the leaves will be short and very far apart like a mullein stalk. Whereas, the seed sown on moist and closely compacted land will produce stocky seedlings with abundant surface rootlets, which will develop an umbrageous, spreading plant, with abundant and more valuable foliage.

Virgin soil is better for the seed-bed than old land, unless the old land has been mulched the previous summer, thereby destroying much of the seed of grass and weeds, which is the chief object of burning the ground. Thorough mulching also restores measurably the virgin properties to old soil. Cold frames and hot beds are sometimes used.

It is important to burn the seed-bed well, in the following manner: rake off leaves and trash, lay green poles four to six feet apart, pile on brush uniformly for kindling if you have it convenient. Then throw on heavy sticks of wood at right angles, with old rails or dry wood between, across the poles or skids, which serve to elevate the burning wood, admitting of oxygen to support free combustion immediately over and near the surface. After the smaller wood has been burned, with a long-handled hoe or hook, draw the remaining large pieces to the margin, and so extend the area of the bed. When it has cooled, dig up closely, leaving the ashes on the ground, being careful not to turn the burnt surface upside down. Do not plow. Then, with prong hoe and rake, remove all roots and small stumps and level the surface nicely, raising it about six inches on the margin by a small ditch to carry off surplus rain. Apply four quarts of any good commercial fertilizer per square rod and rake in.

QUANTITY OF SEED AND HOW TO SOW.

One heaped tablespoonful of good fresh seed to fifty square yards, mixed thoroughly into a half gallon of corn meal or white ashes, so as to see when the ground is well seeded. Better to mark off spaces with a stick about four feet wide. Sow with thumb and two fingers, when no wind is blowing, and leave a little to sow across the other way to insure uniform stand. Don't rake the seed in as some will be too deep, but rather use a long, stiff switch and sweep lightly, and then with a pair of quickly extemporized snow-shoes (made by nailing a strap for the foot on a piece of board 10 by 12 inches), tramp the bed over evenly. Leave the margin slightly raised to run off surplus water.

For protection from frosts, cold winds, flea beetles, etc., it is safer to cover with thin, cheap cotton cloth. This also secures greater uniformity of moisture and temperature. While covering of straight, leafless brush may suffice, the canvas is far better, for it will insure earlier plants. But the canvas must be removed at least ten days or more before the time of transplanting, otherwise the plants would be too tender. Always aim to have twice as many plants as you need.

THE KIND OF LAND BEST ADAPTED TO CIGAR LEAF.

There is no longer any question that new, gray hammock of sandy loam is the best; and if bright wrapper is wanted, even this should have a yellow or light-colored subsoil, either clay or sand, the latter being preferable for growing leaf of the finest texture. But any good sandy loam in Florida, if not too wet, may produce good cigar tobacco, if not impregnated with the limestone (Tertiary) of north and west Florida, or with clay in the surface.

As in the mineral kingdom, the most precious metal, gold, is never found disassociated from silica, (sand), so in the vegetable kingdom, the finest qualities of texture aroma, flavor, etc., are only to be produced from silicious (sandy) soils, unmixed with the baser calcareous, ferruginous, and argilaceous elements, i. e., lime-stone, iron and clay. However, if a sub-stratum of clay occurs, one foot or more below the surface, it is no disadvantage, but may be a mechanical benefit, in supporting moisture.

It is also a fact that the finest cigar leaf in the world is grown only on tropical and semi-tropical Islands and Peninsulas e. g., Cuba, Sumatra, Florida, etc., where much of the make up of the soil is marine drift, and the climate is warm and humid, for it is known to experts in cigar leaf that it requires a humid atmosphere from the seed to the cigar and the reverse is deleterious, and if continuous, is ruinous.

NATURAL INDICATIONS OF CIGAR LEAF LANDS.

Without proper soil, climatic conditions and environment the best results need not be expected. There are fortunately a few easily recognized natural indications that will not mislead. Where there are flowing springs of pure soft water, lime-stone, of course is not present, or the water would be hard. Again the indigenous growth of the virgin forest—the chinquepin, chestnut, hickory, beech, dogwood and oak indicate the best cigar tobacco lands, as well as the best bright plug wrapper.

PREPARATION OF THE LAND.

It should go without saying that new ground should be broken both ways with the "jumping coulter," with a blade in front to cut all roots possible, and that the roots should be raked and burned on the land. That virgin soil produces the very highest results in quality cannot be gainsaid. But if old lands are to be used they should be thoroughly mulched the summer before with a heavy crop of pea vines, which not only clothe the soil as with a garment to protect it from the sun, but absorb and husband the nitrogen and carbonic acid from the air, imparting it and other virgin properties to the soil. Lands thus treated should not be plowed until February, then with a two-horse plow, with a rolling coulter, turn under the vines. It is better to run a cutaway or disc harrow over, to cut up the vines or other trash before plowing under. Let the land remain rough till a few days before the plants are ready to set; then dress with the cutaway or disc harrow, and lay off rows 3½ feet apart, for Vuelta Abajo, and four feet apart for Sumatra and old Florida, and make a slight ridge if the plants are to be set by hand, and knock off same with a board-plow or hoe, and set plants 12 to 20 inches apart, according to variety of leaf and strength of soil. If a transplanting machine is to be used, which I always use when stumps are out of the way, the land should be rolled or dressed with a harrow, float or brush. The machine marks off the rows. There are some good machines for transplanting, notably the Bemis, made at Dayton, Ohio. Also some cheaper ones claiming merit.

WHAT FERTILIZERS MAY BE SAFELY USED.

Commercial fertilizers, as a rule, must be avoided in cigar leaf tobacco, for unlike plug tobaccos, this must have at least four essential qualities, to-wit: flavor, texture, uniform color (without white veins or calico spots), and last, but not least, burning quality. It may have all of the former in the highest degree, and without this burning quality, be utterly worthless for cigar purposes. A cigar requiring two men, one to smoke and the other to hold the torch, would not be in demand. Ordinary commercial fertilizers contain saline properties, preventing a free burn, or still other deleterious slaughter house properties, affecting the aroma or uniform color. That fertilizers should be used with great caution may be demonstrated by the use of German kainit, which prevents burning altogether; or hog-pen, "night soil," or goat manures, giving the "aroma" (?) of a pole cat to the cigar. So it appears, from the foregoing, that all efforts to enrich the soil should be made with the sole view of restoring the original properties of the virgin soil, which, of course, were mainly from vegetable sources. This is helped by shading and mulching which acts mechanically to generate humus, absorb and husband nitrogen, etc., as well as to prevent the sun from evaporating these from the soil.

HOW TO APPLY FERTILIZERS.

Whether broadcast or in drills is the question often asked. Unless the manure is well-rotted and pulverized, broadcast is the better way. But never use stable or barn-yard manure on cigar land, unless the soil is sterile, and then only a light dressing broadcast. This is given, not to feed the plants, but for the purpose of inoculating the soil with nitrifying bacteria by whose agency the sterile soil is quickened and enlivened. If strewn in the row distribute with a bull-tongue plow or pitchfork, so as to prevent "caking" or drying up the plant, of which there is no danger if scattered broadcast. When crushed cotton seed or cotton seed meal is used, first prepare the land well, lay off the rows, (3½ feet), then scatter broadcast and throw two furrows on the row, then what remains outside will be worked up in contact with the roots.

HOW MUCH FERTILIZER PER ACRE?

In New England two or three tons of fertilizers per acre are used, and they get 1,200 or 2,000 pounds of tobacco per acre, which can be done just as readily in Florida with the same liberal application of manure and the same type of tobacco.

TRANSPLANTING.

When plants are three to six inches high, they are ready to be put out, in the same manner as cabbage, fifteen to eighteen inches apart in the rows, which are 3½ to 4 feet apart. If a "peg" is used, let it be short and blunt, and don't make a hole deeper than the plant is to be put in, and press the dirt closely against the roots and not the stem. The plant should be put in nearly up to the bud, however long it may be, for it cannot do well on stilts. In order to make fine texture the land must be rich, and the plants crowded fifteen to eighteen inches, and, if new seed from Cuba, even ten to twelve inches apart in the row, so that there will be 10,000 to 12,000 plants set out to an acre. Plug tobacco should be set 2½ to 3 feet apart, in 3½ feet rows, and land should be very rich. It is impossible to make tobacco of fine silky texture without crowding the plants. Follow in three days with a basket of strong plants and a bucket of water, if need be, in order to secure a perfect stand at once, for whenever there are missing places the plants on the border thereof are apt to be thick and leathery.

CULTIVATION OF THE PLANT.

About ten days after transplanting, go over with the hoe, carefully removing the grass from near the plant, drawing the soil a little around it. The sweep and cultivator are the best plow to use in cultivating, where there are no stumps. The horse-hoe is the best implement, and is used in all the seed-leaf states. (Made by Morgan & Bro., West Springfield, Mass). Cultivate the plants while young with plow and hoe, working the soil always to the plant, and lay by with a hoe in the same manner to keep plants from blowing down, and cease to cultivate after it has all been topped, as too much plowing and cultivating will sometimes make it too thick and leathery, for the chief aim in cigar leaf wrappers should be to make the greatest possible number of leaves to the pound. Three hundred perfect leaves to the pound would better be worth $1 per pound than 100 leaves 30 cents. Cigar leaf should not be plowed as much as plug leaf, as plowing makes it heavier, as the roots are pruned more than by hoeing. Aim to make, if possible, every leaf a perfect wrapper, as wrapper leaves are worth more than three times as much as imperfect leaves or fillers.

WORMING.

The cut-worm will appear soon after transplanting, sometimes the next day. The most effectual remedy is Paris green. Mix one tablespoonful with a gallon of corn meal or flour, and sprinkle the plants, using a perforated tin can as a pepper box. Mix the Paris green and meal twenty-four hours before using. The bud-worm appears next. Use Paris green in the same way. There is no other known way of destroying this most pestilent enemy, and he must be anticipated, for a hole the size of a pinhead will grow to the size of a dollar, hence the worm must be poisoned in infancy. The horned worm appears first about the first or middle of May. This is the first brood to be dreaded, but not so serious as the next, which does not appear in Florida till about the full moon in July, by which time I aim to have most of the tobacco safely housed. The best remedy for this great adversary to the tobacco crop is cobalt dissolved in honey or syrup, diluted, putting a few drops into some jimson (Jamestown or stramonium) blossoms placed around the border of the field about sunset, on small pieces of board with a few holes, nailed on sticks three and a half feet high. One moth, "tobacco fly," destroyed thus would deposit some 450 to 500 eggs, which hatch in about seventy-two hours. It requires twenty-one days for the horned worm to mature, when it goes into the ground to come forth again in twenty-one days (in summer) another moth to perpetuate her posterity.

INSECT AND OTHER FRIENDS.

The common wasp, dirt-dauber, yellow jacket, hornet, etc., are the best friends of the tobacco grower. I have estimated that one red wasp would earn fifteen cents daily in a tobacco patch. By all means foster and care for them, but do not trust them to take all the worms off. You must imitate the early bird, and catch the worm before the noon sun drives him to a hiding place. I have learned not to use torch fires at night to destroy moth, as more of our friends than enemies may be destroyed thereby.

Were it not for our friends among the insects, birds, toads, etc., we would have no crops often. But there are more that be for us than against us. We must learn who are our friends and cultivate their acquaintance, not make war upon them. Besides those cited above I will introduce to the grower more of the enemies of the hornedworm. One is a steel-colored fly, (Ichneumon) little larger than the house-fly, which deposits its eggs in the back of the worm, causing the worm's death, and the production of a new brood of flies to prey on other worms. The mocking bird, the sparrow and some other birds, domestic fowls, toads, lizzards, etc., are our very good friends in the war against insects. Toads are especially valuable as they work at night when the sly cut-worm comes out to cut off the plants. It would pay to offer the boys a price for every toad they will bring you, then turn the toads loose in the tobacco patch. Ducks are also destructive to cut-worms, as they sometimes dig them out. There is also a slender green cricket, (Oecanthus niveus), about an inch long, resembling somewhat a green grasshopper, but more slender, which, being more carnivorous than herbivorous, feed largely on larvae and moth eggs, and though like some other of our friends they take a chew of tobacco occasionally, they pay well for it by their valuable services.

TOPPING AND SUCKERING.

As soon as the blossom appears well, break it off, leaving fifteen to twenty leaves. On plug tobacco leave ten to twelve leaves only, not counting the sand or ground leaves, which some "prime" off, but if the land is sandy leave them on to protect the upper leaves from sand. If the bud-worm has attacked a plant, and injured it seriously, cut it off near the ground and let a sucker take its place, which will do well surprisingly soon. All the plants will not do to top at once, neither to cut at once, unless the later topping is made lower, which causes the leaves to spread and grow too large.

"Suckers" will soon appear after topping, which must be broken off when three or four inches long. Some varieties put forth the second and third sucker, some only one crop. The Vuelta Abajo is ready to cut after the second crop of suckers is removed.

HARVESTING.

Tobacco is ripe and ready to cut when yellow spots begin to appear on the surface of the leaves, or when it will snap or break when pinched between the thumb and finger. Cigar leaf, unlike plug leaf, should not be over-ripe—better cut a day or two too soon than to let it get over-ripe. Sumatra and Old Florida are not to be cut, but the leaves should be "primed" off. (See chapter on Sumatra).

The plant should be cut with a sharp, strong knife, entire and not split, as some do. The Sumatra Wrapper and old Florida Speckled Wrapper, which grow much taller and bear many more leaves than the Vuelta Abajo, should be "primed." In some respects cigar leaf needs the very opposite treatment from the plug leaf, i. e., the former should run two or three hundred leaves to the pound, the latter twenty to thirty. The former needs humidity all the way through from the seed to the cigar, and often water is used to wet the barn floor, whereas the other needs a furnace. Cigar leaf must be bulked almost damp, the other almost dry; so let no one be led astray by agents of patent barns and flues from plug districts, or laborers therefrom. My own experience in Virginia, North Carolina and Kentucky, misled me in my first experiments in cigar leaf.

Never cut tobacco while the dew or rain drops remain on the leaves, as black spots will result. I prefer to cut in the afternoon, as the sun is getting weaker, for in the forenoon, unless cloudy, there is danger of sunburn, which will result in ten minutes just before noon. Before and after the plant is cut be careful to remove every worm, as they will destroy the tobacco if taken into the barn, i. e., cigar leaf to be air-cured. If the ground has not been cultivated for two or three weeks before cutting, there will be a nice carpet of young grass on which to lay the tobacco when cut; don't lay it down in the sand or dirt—select a shaded grassy place and after it has wilted so as not to break, lay it very carefully on the straw on the floor of the wagon, and when a medium load is on, cover with a sheet or some weeds, so as to protect it from the sun while enroute to the barn, where it must be placed on some straw or a rug very carefully, till the hand who must remain there has speared it on the laths and put it closely up on the bottom tier poles where it may remain till next noonday, when it should be carried up and adjusted on the upper tier poles. It should be put about six inches apart on the laths, and they about seven or eight inches apart on the poles.

CIGAR TOBACCO BARNS.

All barns should be convenient to the tobacco field. For cigar leaf, never build one less than thirty feet wide and sixteen feet high at the sides, and as long as you please. You cannot safely let tobacco remain on the bottom tier poles in this climate, as it would be liable to mould in wet weather. A barn thirty-two by fifty, with sixteen feet posts and siding, is sufficient for five acres, ordinarily. The first cutting may often be stripped and boxed to make room for the last cutting, as it will do to strip in thirty-five to forty days if not very large. The tier poles should be ten to twelve feet long.

Pine poles four or five inches in diameter, removing the k with drawknife, make the best poles, and even good rafters. posts should be 4x6, if sawed, and put on sills, which is the on the outside. The two rows on inside (for there should be r rows of posts to have three spaces—a driveway in the middle) may be cut from the pine or cypress forests and placed on a block, or 4x4 studs or sills. The middle posts should be twenty feet long to give pitch or slope to the roof. The eaves should project twelve to eighteen inches, also the gable roof. The roof must be ventilated at the top, so as to allow the hot air to escape, otherwise the tobacco will char or "pole burn" near the roof. The laths should be four feet and two inches long—poles four feet apart, and three and one-half feet one above the other—the first one five and one-half feet from the ground floor. Windows should be made between each post, which should be eight feet apart. They should be as long as possible and the width of three boards, say thirty or thirty-five inches wide and eight or ten feet long, hung with strap hinges on top to push out at bottom every night and close every dry day while tobacco is hanging.

Barns for curing plug tobacco may be built of logs cheaply, twenty feet high, and daubed with clay. The entire cost of a barn twentyby thirty, and twenty feet high, need not exceed $35 to $50 including the furnace and flue pipes. One flue barn out of four is sufficient, as the tobacco may be cured in forty-eight hours and removed to the stripping barn, which should have a cellar or "ordering room" near or under the stripping floor.

STRIPPING AND BOXING.

Cigar tobacco is ready to strip from the stalk even before all the green has disappeared from the stalk, but not until the stem of the leaf is cured. By opening windows every night in July and August in Florida the tobacco will be soft or "in case" every morning, when enough should be taken down and covered to last the strippers for one day. Beginners should make only three on four

GRADES OF CIGAR LEAF.

First, wrappers (perfect leaves); second, binders (partiall
perfect leaves); third, filler (ragged and all imperfect leaves). T
fourth grade should be the trashy leaves which, if sold at a
should not be included with the crop. Always give the low

grade the benefit of the doubtful leaf. The best plan is to take off all the imperfect leaves first, leaving those with apparent wrapper qualities for more critical examination. Bind in "hands" (or bundles) of twenty to thirty leaves of even length and quality, and keep under cover till noon or evening, when it must be put into the boxes straight and compact, lapping tips about six inches, and let the butts be about one inch from the ends of the box so as to allow the heat from the sweating process, which begins at once, to escape. Keep tobacco in boxes covered with cheap oil cloth while stripping, as a case or box may not be filled for several days. When full fit boards and press down by standing on boards, or a small lever may be used. When the box is full it is ready for the local buyer, who expects to re-handle it in his own warehouse (until the average Florida tobacco grower has learned to grade more accurately) and sweat and otherwise prepare it for the manufacturer, or the greater markets of this and foreign countries. When the leaves are primed off in the field the grading can be partially done in stringing them. So that if sale is made in the crude state there is nothing to do but to push the leaves to the middle of the cord and wrap with same, and the goods are ready for delivery. If you expect to sell early to local warehouse dealers little grading is necessary, only to keep the sand leaves separate.

It pays the farmer to sell quickly and take a few cents less and let the local dealer re-handle and grade more perfectly, and sweat it or "betune it," thereby relieving the planter of a task he cannot well perform; if indeed they will pay him a fair price, otherwise he would better have it sweated or betuned and prepared for the manufacturer. Sometims one hundred to five hundred per cent may be saved in this way.

These rules for stripping, boxing, etc., do not apply to bright plug leaf tobacco, which is to be "prized" into hogsheads of 750 to 1,000 pounds. Kiln-dried tobacco will not keep sound if the stem is soft when bulked or prized; the stem should snap when bent between the fingers. Air-cured tobacco may be boxed when ite damp, for the fabric of the leaf, the cellular tissue, has not been broken down by intense fire heat ,as it is of the kiln-dried or flue-cured.

Never undertake to soften or bring tobacco in case to strip or handle by "sprinkling or pouring," much less by "immersion." Nevertheless, if the weather should be dry and windy, and should so continue, your crop will be in great danger (in Florida) of injury from evaporation and deterioration, beoming dry and harsh or "bony and crusty." It should be put into the cases (boxes), which should be two or two and a half feet wide and deep, by three or three and a half feet long (but not made of pitch pine, as it will impart the turpentine odor), by or before the end of October or November (unless it is a fall crop, which is possible). It is important, to obtain the best results, to put Florida cigar tobacco in boxes before its "life blood" has been evaporated by hanging too long on the poles. In other words, its inherent moisture (sap) should be conserved by early stripping and boxing, for therein consists the secret of preserving the life, aroma, brilliancy, and elasticity of the article, which keeps it soft, rich and mellow, besides preventing its corruption and consumption by moth and rust; for if this rule is not observed, and the tobacco is put up in a declining condition, so it will continue until within a year or two, when the little white worm, the offspring of a little beetle (Lasioderma serricorne, Fabr.,) sometimes seen in old cigars made of poor, lifeless tobacco will attack and consume it. Here, then, is a dilemma if the weather is dry and windy, and the question arises

HOW TO SOFTEN THE TOBACCO

without spraying or sprinkling, which would often ruin it? For $5 or $10 (or none if you do the simple work yourself) you may have a softening room in one corner of your barn, or on the outside, by digging a pit about five feet deep, by ten or more square, in the ground. If clay, no wall of logs, boards or brick is needed. Build above ground about three and a half or five feet an air tight wall. The roof may be nearly flat, and may be covered with the earth taken out of the pit. Have only one opening or door. Put tier poles or light strips in this room, and place on them a sufficient quantity of tobacco to strip next day. It will become soft and pliable in one night.

BRIGHT PLUG WRAPPER.

It has already been demonstrated that Florida soil and climate are probably better adapted to the production of fine bright plug wrapper, "cutter" (cigarette), and pipe tobacco than even Virginia, North Carolina or South Carolina. The soil, climate, seasons, and immunity from storms and frosts, which very often cut short the crop in those States, make Florida, especially North Florida, preeminately the New Eldorado of the United States for growers of these types of tobacco, and the fact that they always command a ready cash market at from ten to one hundred cents per pound should stimulate the growing of them extensively in Florida. Scores of young men from Virginia and North Carolina are ready to come to Florida for this purpose at fair wages. Any practical farmer can learn it in one year by close application. The foregoing instructions on cigar leaf from the seed-bed to setting it out, are applicable to plug tobacco, which should be planted about 3x3½ feet, and topped at 8 to 10 to 12 leaves. This and the curing process and the "prizing order" or case, constitute the main points of difference.

The only reason for flue curing or kiln-drying, is this: Everbody knows that the green foliage of trees and plants must turn yellow before it gets "brown and sere." Now the object of the flue or furnace is to raise the heat in the barn rapidly, when the tobacco has turned yellow, and fasten the yellow color in the leaf and stem within forty-eight hours or less; then it may be removed into the stripping barn, and the flue barn may be used for the next cutting.

PLUG TOBACCO BARN.

These flue barns may be built of logs or boards 1x10 or 12 inches, 18x20 feet, and twenty feet high, closely battened. They may be daubed with clay. The expense need not exceed $35 to $50. The furnaces may be built of brick or rock each side of the door, 18 to 20 inches high and about six feet long—opening under an arch or heavy sheet iron top from the outside, in which the fuel is to be burned. The flue pipe, 10 or 12 inhes in diameter, is connected with the furnace reaching to back side of the barn and returning parallel, through the wall near the door and turned up about six feet for chimney. A thermometer must be used to regulate the heat.

The best types of bright plug leaf are the Long Gooch and White Stem Orinoko. They can be bought of the Ragland Seed Farm, Hyco, Va., at about $2.00 per pound, and they can be relied on as fresh and genuine.

NOTES.

1. Page 411 Sumatra seed, being more tropical, should not be sown in north Florida till February 15 to March 15, and the beds should always be covered with canvas to keep a more even temperature. It is thought that this type should be planted about a month later than others mentioned. When the seed has become acclimated they may be sown earlier.

2. Page 414. The effects of limestone on tobacco should be better understood. Different limestones, differentiate the soils by their disintegration. I see that some Cuban experts are lookng for Calcareous surface rock as indication of tobacco lands that will give combustivity. They will find, perhaps too late that the oolite rocks of Cuba affect the soil quite differently from the massive rotten limestone of Florida.

3. Page 415. If enough cotton seed meal be used to get, say 150 pounds of potash per acre, the meal would yield so much nitrogen that the leaf would be coarse and dark, and everyone knows that dark leaf of equal quality will not command half as much as light colors.

4. Page 420. To the direction not to break off leaves in the fields, the Sumatra and old Florida wrapper are exceptions. They grow much taller, and in order to secure the bottom leaves before the top ones ripen they should be "primed off" and taken in la e flat baskets to the barn, and strung on slender laths, cord, r

wire. I prefer wire cut into twelve inch lengths and pierced through the large end of the stem, the leaves being put face to face or back to back, not "spooned." Put three of these astride the lath and hang on poles. (See chapter on Sumatra Tobacco).

5. Page 423 "Kiln-dried" or flue-cured" will not stand the moist ferment or sweating process necessary for cigar leaf. It would very soon "funk," blacken and rot, for the fabric or cellular tissue was destroyed by the intense heat.

FURTHER DISCUSSIONS.

TOBACCO SOILS.

There is probably no plant in the vegetable kingdom so susceptible of variation in type and quality as the tobacco plant. Different soils, and different manures, and different climates, with the same treatment, will give a different quality even from the same seed. Manures and manipulation may be changed to secure a different and better quality, but the geological character or structure of the soil, and the climate cannot be altered; hence it is of prime importance to seek first of all, a suitable location with reference to these.

More particularly and necessarily must the geological nature of the soil be considered and understood, for no manner of manipulation, manuring or climate can give good results if this fundamental element of the soil be unsuited. As the varied rocks give varied mineral qualities to springs and wells of water, so they vary the soil, and the texture and other qualities of the tobacco leaf. I will simply state here that it has been abundantly demonstrated that the oldest roks in the earth's crust, as they chance to occur on the surface, produce the finest results, while the later limestones produce coarser grades or types, as a rule.

FERTILIZING.

It is not the aim of the expert grower to produce simply a good crop of tobacco, but more particularly a crop of good bacco; and while we must not undervalue the importance of h ing a large quantity, the quality is more important; however, latter is more apt to associate itself with the former than wit small yield in weight, for a small yield, per acre, is very apt to be of poor quality. Therefore, in order to insure both quantity and quality I find it necessary (with very few exceptions on some of the richest virgin soil) to apply liberally the elements of plant food well-balanced and adjusted so as to constitute a perfect aliment, readily soluble, so that the delicate rootlets, or feeders, may appropriate and the plant assimilate it very quickly, as the tobacco plant is very short lived; sometimes maturing within forty to fifty days, when all the conditions are favorable

CHANGES IN TOBACCO AND IN TASTE.

In Florida, tobacco oten grows wild, seeding itself from year to year, showing that it is entirely at home in this soil and climate; but all florists know that wild plants and their flowers and foliage may be vastly improved by repeated transplanting, cultivating and feeding. With none is all this so important as the tobacco plant, to perfect its many virtues. This is rendered more so from the fact that as civilization and education advance the tastes of people are more sensitive, and the vagaries of fashion more exacting. Fifty years ago almost any tobacco, not too strong or too weak, that would burn in a clay or corn-cob pipe, or stogie smoker, was satisfactory; but now the cultivated tastes of palate and olfactories and eye are all to be catered to. The goods must be sweet, aromatic and pretty as a polka-dot, smooth as silk, glossy as satin, and as thin and elastic as a bat's wing. And having all these qualities in the highest degree, it will be utterly worthless unless it burns well. And the burning quality must also be qualified, for the ash must be white and solid like a chalk pencil, must not split and flake and fall all over a gentleman's coat and vest; nor is this all—the cigar must hold its fire a long time, and not coal; five or six minutes being a high rk.

And so it follows that the quality of perfect combustion is most essential, while all are important and must be consid- d in the compounding of this complete, well-balanced, highly soluble, nutritious prepared food or fertilizer for this delicate feeder which cannot disintegrate or assimilate anything crude.

CHEMICAL MANURES.

Hence it follows that the best combinations for fine vein, silky texture, aroma and free burn with solid white ash, are to be chiefly obtained by use of chemical manures; not because their component parts are individually better, but for the reason they are generally more highly available. It does not seem to make so much difference in what form the phosphoric acid is, so it is freely available, but the acid phosphate is possibly to be preferred to the animal or slaughter-house product for cigar leaf. But we are to be more particular in the selection of the best form of potash and nitrogen. Of all forms of potash the muriate, kainit and all crude forms are most objectionable, for the reason that they carry too much chlorine. It would seem that nitrate of potash would be preferred on account of its ready form, but the same objection holds against its use, as it comes from the Chilian mines, and the expense of refining and eliminating the chlorine is too great. The fact is now so well established that chlorine is deleterious to the burning quality of tobacco that it should go without saying that all elements of plant food containing it, as all forms of ordinary commercial fertilizers do largely, must be avoided.

POTASH, PHOSPHORIC ACID, NITROGEN.

My own experience compared with the careful experimen that have been made by several experiment stations, notab the Connecticut Station, convinces me that the double manu salt, sulphate of potash and magnesia, is to be preferred to a other mineral salts, even to the high-grade sulphate, probably its combination with magnesia. It is also the consensus of opini that potash is the principal element in a complete and well-b anced aliment for cigar leaf, and should be nearly double that of phosphoric acid and nitrogen, and while a slight excess of either one of the latter will injure the leaf, the same cannot be said of potash. I have noted that excess of nitrogen increases the per centage of nicotine and albuminoids and produces a coarse, dark leaf, with large ribs and veins, and more particularly is this rankness attributed to stable and barn-yard manures, and for this cause many scientific writers advise against their use altogether. But while I am convinced that this is correct in the main, I would not entirely abandon stable or barn-yard manure for cigar tobacco, though I would never use it except a very slight dressing, and that not as a plant food at all, but simply to supply a needed agency in the form of micro-organisms to inoculate a sterile soil with the nitrifying bacteria.

AN EXCESS OF PHOSPHORIC ACID.

I have noted more than once on certain fields where soft and soluble phosphate boulders and pebbles cover the surface, that tobacco attains a most rapid growth. As soon as this tobacco is topped the rootlets seem to extend rapidly outward, and the remaining leaves come to quick maturity. Then, often, in a few days the whole plant "fires" from top to bottom, so that it could easily be ignited on the hill. Just across a small stream, where these boulders do not occur so abundantly on the surface, and where there is a light application of prepared tobacco food, carrying ten per cent actual potash, no such symptons occurred. So I am convinced that there are some lands in Florida with a too abundant supply of phosphate for tobacco.

LIME.

have never underestimated the necessity of lime in its
er form. (Corborate). Indeed, I venture the suggestion that
unctional importance in the soil has not hitherto been appre-
But the rotten limestone found on the surface in some

sections of Florida is extremely deleterious to cigar leaf. In my opinion the attempt to grow the finer qualities of tobacco on soils containing a considerable amount of this rotten limestone (tertiary and quarternary) will surely fail.

CLIMATE.

That the length of the summer season, the temperature, the humidity, or in a word, the climate, is an essential factor in the production of a perfect cigar leaf, cannot be questioned. This climate should be tropical or semi-tropical, for example Cuba, Sumatra, Borneo, Mexico, Florida. That fine aromatic flavor and odor, which are necessary to a perfect cigar leaf, are due as much to climate as to soil. The structure and conditions of the soil may be perfect, but disassociated from perfect climatic influences they cannot produce the fine aroma so desirable in cigar tobacco.

To conclude this discussion it may be well to summarize the essentials to the production of perfect cigar leaf, that is filler, binder and wrapper:

1. Tropical or semi-tropical climate.

2. The selection of the best strains of the best variety of seed.

3 .The selection of soil of light sandy loam, well drained, free and friable, with no crude limestone out-cropping; particularly with no loose arenaceous rotten limestone.

4. Near to a body or stream of fresh water to insure humidity from the constant evaporation.

5. Make no application of stable or barn-yard manure plant food, but only a light dressing of that which is well-rotte on sterile soil only, and this for the purpose of inoculating t soil with the nitrifying organisms.

6. Apply a suitable amount of fertilizer, composed of che ical constituents mainly, and well balanced with about two pa pure potash to one of nitrogen and phosphoric acid.

7. Give constant and careful cultivation and attention.

WORK IN 1896.

In reportng the results of experiments and the extent and quality of the 1896 crop of tobacco, I have deemed it best to extend my observations to the various localities of West, Middle, East and South Florida, and not to limit this report to the locality of the Experiment Station, for the reason that it was impossible to conduct such experiments as seemed needful wih the limited amount available for this purpose. Moreover, the season was very unfavorable, and the Agricultural Department of the State under the judicious management of Hon. L. B. Wombwell, reinforced by most of the railroads, particularly the F., C. & P. and the P. & A., seeing Florida's greatest opportunity growing out of Cuba's extremity, distributed seed freely throughout the State, and also many copies of the Bulletins of the Station. In addition to all this President Duval of theF., C. & P. Railroad appointed a special agent, Mr. Henry Curtis ,of Quincy, to devote his whole time to the encouragement of tobacco growing from the Chattahoochee river to Tampa Bay, particularly in many southern counties where little has been done hitherto in tobacco growing. President Duval sent a man three years ago to the Island of Sumatra and obtained, at great cost, some of the finest strains of seed, and distributed them freely through Mr. Curtis, throughout the State. Other railroad companies also distributed the best seed that could be obtained of local growers, and some from Cuba.

SEASON OF 1896.

Commissioner Wombwell estimated that he distributed seed to at least four thousand three hundred applicants; over one hun- ed pounds of seed at a cost of at least five hundred dollars for seed alone. His estimate was that about ten thousand acres ld be planted in the State in 1896, but the unprecedented ught of last spring, extending from March to June, made it ossible to plant out over half this estimate; and of course most hat which was transplanted suffered more or less. Much of y planting had to be cut off near the ground and start a new sprout, "sucker," because the original stalk had become woody and wirey for lack of rain, and therefore could never have developed into a merchantable article.

TIME FOR GROWTH OF FLORIDA TOBACCO.

At this point it may be pertinently noted that the period required for the development and maturity of the various types of cigar leaf grown in Florida, in the spring and summer months, is from forty-five to sixty-five days, under the most favorable conditions, i. e. proper fertilizing, cultivation, moisture and temperature. If any of these four essentials be lacking to any extent the development of the plant is correspondingly checked. Again, I have observed that when a crop of tobacco has attained nearly its full growth and a serious dry spell occurs and the plant suffers and begins to turn yellow, and then if plenteous rains occur and the crop takes on the second growth and turns green again, the maturity is not only delayed but the leaf is greatly weakened in its fibre and fabric, and is liable to stem-rot more or less. This tendency, however, is greater in some varieties than in others, and I am impressed that the Sumatra leaf is less liable to this weakness than some Cuban types. Notwithstanding all these drawbacks a very fair crop was produced, aggregating about one million pounds merchantable leaf, from less than five thousand acres, most of which, outside of Gadsden, Leon and Columbia counties, was purely experimental, grown by beginners or novices in the art, without experience and without proper drying sheds.

These beginners, as could have been suspected, are not altogether so much encouraged as the more experienced growers most of whom will increase their output in 1897. Nevertheles the majority of these beginners in South Florida made fine crop many of which were sold in the crude state at sixty cents p pound, average. It is a remarkable fact, and the same cannot l said of any other tobacco district in the United States, that th bulk of the crop, about ninety to ninety-five per cent, was in hands of leaf dealers before the middle of October. Most of it sold in September, within one hundred days after being transplanted, and within forty days after harvest. Whereas tobacco crops grown in other states are generally held by the producer from eight months to three years. When the risk, loss of weight and loss of the use of the amount of capital invested are all considered, it will be seen that Florida tobacco growers enjoy an advantage of great value.

LOCAL WAREHOUSES.

This great advantage, however cannot be enjoyed unless there are local warehouses at central points, where the crops are bulked, fermented or "sweated," and then graded, and then baled or boxed for shipment. Five to ten thousand pounds are necessary for a good sized bulk to generate sufficient heat to cause the ferment. Tobacco should be fermented just as soon as the leaf is once dry, before the inherent moisture has evaporated. For this reason buyers are on hand in August, September and October, and will pay well for crops thirty-five to fifty days after harvest. And as they take it as it comes from the poles, unassorted, the producer can afford to take less price, as he gets pay for full weight without delay or further labor or risk. It is estimated that the shrinkage in the ferment, and loss of worthless leaves in sorting and grading, will amount in all to fifteen or twenty per cent, and in poor crops to over twenty-five per cent.

ASSOCIATION OF GROWERS.

If neighborhoods would associate themselves together, cooperate and employ an expert manager (I mean a man "expert," with experience in Florida, for experience elsewhere only ld mislead him), and grow not less than forty to fifty acres in ighborhood, buyers would come and erect warehouses. Or association themselves could do this and finish their own duct, and put it on the market and realize the profit the leaf dealer would get. No doubt this will eventually be done, when the growers have more experience; but till then, better let the middle man have this part of the work, though he gets the lion's share of the profits. And upon business principles, if his superior skill, enterprise and capital gain this advantage for him, he is entitled to it, and he will perforce hold it until the producers learn to cooperate and finish their own products for the manufacturer.

DEMAND AND SUPPLY.

The indications all point unmistakably to a demand for superior cigar tobacco many times greater than the possible supply for some time to come. It will be years before Cuba can produce a crop. It has become a necessity, hence there will be demand for good tobacco that can be grown in Florida.

DEFENCE OF THE FLORIDA PRODUCT.

Now the question is not whether Florida can produce the Cuban leaf, for while many prefer a strong to a mild cigar, there are just as many who prefer a mild one. It is a matter of taste simply. I have heard many intelligenet Cubans contend that they can cultivate and minipulate the Florida product from Cuban seed and make a superior article to the Cuban. To illustrate the difference between the two: some prefer a blackberry to a strawberry. So with Cuba and Florida tobaccos. The Florida product is more delicate and mild; contains less nicotine, and may be smoked with comparative impunity, as the nervous system is not shocked, nor the disagreeable taste left in the mouth, nor the foul breath caused by the excess of nicotine, ammonia and free carbon present in some Cuban tobaccos.

In proof that these views are correct I will quote from North Carolina Experiment Station, Bulletin No. 122, on "Ty of Tobacco and their Analyses," 1895. This work from North Carolina Station is the most complete and technical in its bearings, from the geological and physical character of soils, fertilizing, cultivation and manipulation that I have seen. To Dr. H. B. Battle ,the able Director, the Tobacco World owes a debt of gratitude for this and other minute and painstaking experiments and reports on samples obtained from every tobacco district in the United States. The sample furnished Dr. Battle from Florida was grown on hammock land which had never been touched with domestic or commercial fertilizers. It was from the sixth crop on the same land. In his table showing the comparative analysis of typical tobacco from all the tobacco districts in the United States, the sample from Florida showed the "highest marks of superiority of any other" except Pennsylvania seed leaf, which exhibited a fraction more potash, but of course that was supplied in the heavy application of fertilizer used, but it showed also more chlorine. It is conceded that the burning quality is the chief point of excellence in cigar leaf. The match was applied to thirty-two different samples at the end of the prepared strips, and the Florida sample was the only one that burned completely out to the other end, consuming the entire strip. The table is herewith appended:

Burning Quality of Tobacco. Showing Glow in Seconds.

STATION NUMBERS.	WHERE GROWN, AND VARIETY OR TYPE.	GLOW IN SECONDS.	
		AVERAGE.	RANGE.
468	N. Y.; Domestic Havana Eureka..	14	5—35
469	Fla.; Cigar leaf wrapper.......	117	Burned to end of strip.
470	Ky.; London strips............	8	5—25
471	Ky.; White Burley.............	7	4—18
472	Mass.; Wilson's Hybrid.........	13	5—28
473	Tenn.; German Spinning Leaf...	11	7—15
474	Penn.; Pennsylvania Seed Leaf..	175	Burned 2½ ins. and put out.
475	Ct.; Havana Seed Leaf..........	16	4—45
476	N. C.; Fancy English Strips.....	5	4—6
477	Va.; Bright Wrapping Leaf......	4	2—8
478	Va.; Austrian Wrapper.........	5	3—8
479	Va.; Italian Regie.............	31	10—90
480	Va.; French Regie Snuff Leaf....	5	3—8
481	Va.; Fine bright mahogany wraper	6	4—8
496	O.; Ohio Spanish...............	24	8—50
497	Va.; Small dark wrapper.......	24	14—50
582	Md.; Colory Seconds...........	39	15—65
583	O.; White Burley..............	4	2—6
584	Ga.; Yellow tobacco...........	4	2—8
585	Ala.; Yellow tobacco...........	6	4—10
586	Kas.; Reddish brown...........	6	4—10
587	Miss.; Reddish brown..........	6	5—7
588	W. Va.; White Burley..........	52	15—150
589	Ill.; See Leat..................	12	4—30
590	Ind.; Light Brown.............	10	5—25
591	Tenn.; Spanish type...........	15	5—40
12	N. C.; bright wrapper, leaf cure	5	3—7
13	" bright wrapper, stalk "	5	4—7
10	" yellow, smoker, leaf "	8	4—13
6	" yellow, smoker stalk "	7	4—14
100	" yellow, cutter, leaf "	8	4—15

OBSERVATION ON BURNING QUALITIES.

"In comparing experiments with regard to the effect of structure and chemical composition upon the burning qualities, the following salient points may be observed:

"1st. The best burning qualities were accompanied by a high percentage of ash constituents.

"2d. The presence of a large percentage of lime in the ash was accompanied with comparatively good burning qualities.

"3rd. Potash existing in proper combination was conducive to complete combustion.

"4th. Other things being equal the burning quality improved as the percentage of cellulose increased.

"5th. As a rule a thin leaf with a delicate structure burned better than a coarse leaf.

"6th. Albuminoids seemed to have a deleterious effect upon the combustibility.

"7th. Nicotine is not an important factor in affecting the burning quality of tobacco.

"8th. It has been demonstrated by different writers that tobacco containing large amounts of chlorine does not burn well. Nessler found that an abundance of potash overcame the effects of chlorine to a certain extent, and this seems to be verified in these results."

In defense of the position maintained hitherto by the writer, in Bulletin No. 30, Florida Experiment Station, as also in other pamphlets and contributions to agricultural journals, which has had many criticisms. I will at this point quote the observation of the North Carolina Station in these experiments. (Bulletin No. 122, page 365.)

"Observation 8. Limestone and clay soils produce rather strong tobacco, with a large nicotine content."

"Observation 7. The land best suited for the production of fine quality of tobacco is well drained sandy or sandy loam."

On page 344 of this North Carolina Bulletin this declaration is made:

"We find here (No. 2) the soil which produced the highest priced wrapper (described on page 354 as very fine texture and very glossy and silky, and color light brown) is a light sandy loam (hammock) without any fertilizer, grown in Florida, where climate approaches that of the West Indies, and the quality approaches more nearly to that of Cuba than any other grown in this country."

U. S. FARMERS' BULLETIN NO. 5.

In confirmation of the above impartial testimony from the North Carolina Experiment Station, it may be well to refer to the "Farmers' Bulletin" No. 5, published by the Department of Agriculture of the United States government at Washington. This Bulletin was prepared by an acknowledged authority, Honorable John M. Estes, of Wisconsin, Special Tobacco Agent of the government. He was employed to make a tour of all the tobacco districts of the United States, and to report facts specially for the the Columbian Exposition. He says:

"We know * * * that for several years Florida has produced the highest grade of cigar leaf."

The editor of the American Agriculturist submitted samples of Columbia county wrappers to a committee of New England experts and manufacturers, who "at once pronounced them the finest in every respect ever produced in the world." This verdict was telegraphed to parties in Florida urging them to "spare no pains or means to develop this important industry."

And in further defense of the Florida product I will only mention the fact that to Florida wrappers and fillers were awarded both medals at the Cincinnati Centennial in 1888. Florida tobaccos have won several times at other expositions. Which proves that the prejudice some have against Florida tobacco has been created by branding Florida's best grades as imported Havana and Sumatra, and selling only the poorer grades as Florida filler.

FLORIDA TOBACCO SOLD FOR IMPORTED TOBACCO.

This fact is often denied and ridiculed; but it is easily esta lished by reference to the circulars and "price currents" of so of the largest leaf dealers and speculators, in which the boast claim is sometimes made that they have every "variety and type grown on the earth," and while they quote "Florida filler" at 45 to 75 cents, I have never yet seen a Florida wrapper quoted, but sometimes Havana and Sumatra wrapper at $1.50 and $2.00 per pound, which is just about the amount of the duty. Evidently they have been selling Florida wrappers under the foreign names. But for such injudicious and false procedure, Florida, tobacco would now need no such defense as the foregoing, but would have had by this time an established reputation, and the crop would be five or more million pounds instead of one. Therefore I have deemed it needful to make this defense to restore confidence in the minds of some discouraged planters, and more fully to advise intending home seekers and investors as to the facts in the case.

FLORIDA SUMATRA TOBACCO.

For many years experiments were made in Florida with Sumatra tobacco seed, obtained through the American Consul at Singapore, but all were very unsatisfactory. Within the last three years President H. R. Duval, of the F., C. & P. Railroad, by sending to the Island of Sumatra, succeeded in obtaining only two pounds of the best strains, from which not only satisfactory but very surprising results have come, that have already revolutionized the growing of Sumatra tobacco in Florida, and promises in the near future either to drive out the foreign invader or to command the same prices in the open markets. And when it is considered that within a single decade after the introduction of Sumatra wrappers that they obtained a foothold on the Amercan markets which even the $2.00 duty did not check, but the demand still increased until at least fifty per cent of the domestc cigars are now being wrapped by them, and causing an annual drain of at least ten million dollars, gold, from the country, it is at once apparent that the advent of the genuine matra seed and its successful culture in Florida is a very fortute circumstance.

PECULIARITIES OF SUMATRA TOBACCO.

The Sumatra tobacco plant is peculiar, differing more widely from other varieties than any other cigar leaf. The imported seed I had sown on the 10th of February, a month later than the Cuban seed. They all germinated and came up well, and looked very promising, but the first chilly night when the thermometer dropped to thirty-eight degrees, they turned yellow; all succumbed to the cold, although there was no frost. On part of the same seed bed Sumatra seed that had been grown in Florida the preceding year were not affected by the cold, being somewhat accclimated.

When it is considered that the Island of Sumatra is situated nearly on the equator the tropical nature of the plant will be understood. Even in North Florida it is not safe to sow the imported Sumatra seed before the middle of March, at which time other varieties may be ready to transplant. But it is under favorable conditions, a rapid grower, and within forty to fifty days will attain the remarkable height of six to eight feet. It has been found by experiment that it is best not to top the plant at all; and if at all, not until about four fifths of the leaves have been harvested, which must be done by breaking them off (or "priming") as fast as they "speck." Let it be noted that the word "speck" is here used for "ripe." Indeed this variety of tobacco leaf must not be allowed to ripen fully, as its texture and toughness, and its popular and delicate pea-greenish huewill be spoiled by deepening into the brown and sere, which is not so valuable as a wrapper only because not so fashionable.

If the leaves are allowed to ripen fully they make a fairly good filler after being well fermented or betuned; better still, after one or more years' reproduction in Florida. This fact is another important feature of the Florida grown Sumatra seed-leaf, for the imported article is not at all fit for a filler, being void of any quality of aroma. Still another advantage it has in Florida is that it grows splendidly in old lands of sandy soil, whereas on the island it is only grown on the new land.

And still another and more important advantage over the

Vuelta Abajo is the more abundant yield per acre. The average yield as per census reports of Cuban seed-leaf in Gadsden County, where it was most extensively planted, was 395 pounds per acre. Now since the advent of Sumatra the yield on some lands is estimated at five hundred to twelve hundred, and some few even claim from twelve hundred to fifteen hundred pounds on new hammock land; but it is conservative to estimate that the yield is about 75 per cent more than the Vuelta Abajo, and it is not at all surprising when it is considered that the plants will average on land properly enriched seven to eight feet high, and thirty to forty leaves to the plant, and that there are ten hundred to twelve hundred plants per acre. By the diligent use of Paris green to destroy the bud-worm and the other pests, which are not generally very annoying, 75 per cent of the leaves may be made wrappers, and the balance binders and fillers. There is a great advantage in gathering the crop leaf by leaf, giving an opportunity to inspect every leaf in the harvesting, and again in the stringing process in the barn. This is accomplished in the rainy season. This season comes in Florida in the harvest time, from June to September, about ninety to one hundred days, and this is another great advantage in Florida, for if the harvest were to come in a dry season, as in Cuba, artificial means would be necessary for the proper curing or air drying of the leaf. All tobacco growers know that the drying should be slow, and in a humid atmosphere; for it is conceded now that cigar-leaf, especially wrappers, should not be allowed to get very dry more than once; and as soon as the green has disappeared from the mid-rib it should be bulked and completely sweated in the first heat by its own inherent moisture or sap, which is really its very life-blood, and should be thus conserved, and not allowed to evaporate on the poles and thus waste its fragrance on a desert air. To illustrate this fact, any good cook knows that a loaf of bread, a potato or a roast of meat would be unfit to eat after being half cooked and allowed to get cold, then finished with another fire. So it with the curing or fermenting process of tobacco. The first rocess should complete it, and that should be done just as soon s possible and in large bulks in a close apartment with a temperature from 90 to 130 degrees. Yet if it is packed in large boxes closely and in high case (soft), and the boxes stored in a close warm compartment, the leaf being thin it will generally come out all-right in the course of forty to sixty days, and be ready for use by the casing, which all manufacturers give it in the process of de-stemming and booking, or if it is taken out of the bulk at the proper time and baled under press, it will be ready for the table when it reaches the factory, in say fifty to 100 days. I have seen of the '96 crop hundreds of thousands of pounds that will run seventy-five per cent wrapper, and as fine in every respect, to all appearance, as the imported! And yet they say it would be too bold if the truth and nothing but the truth be told. Well, the "finishing touch" is to pass it through ports of the Amsterdam Dutch, and so pass it off for imported Sumatra. But the time will come when the Amsterdam and Breman Dutch, and other foreign leaf dealers, will come back to Florida, as in ante-bellum days, to buy fine speckled wrappers, and for which they invented or discovered Sumatra as a substitute after the ports of Florida were blockaded in 1861, and they could not get Florida leaf. But there is no doubt that some of the soils of Florida and the climatic conditions are superior to those of Sumatra and the same skill with the same types will yield superior results in Florida. Florida has been robbed of the credit of producing "the finest leaf ever grown in the world." The best product having been disguised and sold as Sumatra and Havana, and only the inferior grades and trash sold as Florida leaf! And the very performers of this ingenious though un-patrotic trick of trade now confess that it was a blunder, and they themselves regret it. But Capt. General Weyler's edict, forbidding the further exportation of tobacco from Cuba will force the Florida Cuban seed leaf on its own merits. This will prove to be a very fortunate edict, as the prejudice created against Florida tobacco by the injudicious course pursued by so many speculators hitherto will now react in our favor.

The following tabular statement in detail will illustrate ir theory what has been demonstrated in practice. I believe it wa done on the noted Santa Clara Plantation of the Owl Cigar Company near Quincy, on which no less than one hundred and thirty acres were under the skilful management of Mr. Corry, to whom, with Col. Henry Curtis, agent of the F. C. & P. railroad, I am indebted for courtesies and valuable information.

The Owl Company showed its wisdom in employing managers with experience in Florida,—men who understand the soil, the seasons, the climate, the labor.

DESCRIPTION OF A TYPICAL SUMATRA PLANT AND ESTIMATE OF YIELD PER ACRE.

Height of plant when topped, 6 to 8 feet.
Heigth of plant when in flower, 8 to 10 feet.
(a) Length of longest cured leaf, 18 to 20 inches.
(b) Length of shortest cured leaf, 8 to 10 inches.
(c) Average, 14 inches.
Width of leaf (a), 10 to 12 inches.
Width of leaf (b), 5 to 6 inches.
Average width of cured leaf, 8 inches.
Greatest number of leaves on best plant, 40.
Lowest number of leaves, 20.
Average number of leaves, 30.
Average bottom or sand leaves, unmerchantable, 3.
Average top leaves worm-eaten or otherwise injured, 7.

Weight of the average number of the merchantable leaves from one plant, 1 3-5 ounces.

Distance apart in row, 12 to 15 inches.
Distance of rows apart, 4 feet.

Number of plants per acre, if full	10,000
Failures from cut-worms and other causes	2,000
Average stand	8,000

If one plant average 20 merchantable leaves and weight is 5 ounces, then

Two hundred leaves weigh a pound, and one acre produces 160,000 leaves and weigh 800 pounds.

If two-thirds are wrappers we have 600 pounds or 120,000 leaves, that should average three wrappers per leaf,—360,000 wrappers. If one pound of 200 leaves cut 600 wrappers, then less than two pounds cover one thousand cigars. If this was imported it would cost from $5.00 to $6.00.

COST OF PRODUCTION.

In all economic industries the question of prime importance is the cost of production as related to the market value. The price of the land, the plant food to be applied, the labor, and the lumber to construct sheds, etc., are the main factors entering into the cost of production of cigar-leaf. It was noted in the special reports made for the Columbian Exposition, that in Florida, where the finest leaf in the United States is grown, the lands are the cheapest. In the Connecticut and Housatonic Valleys, in the seed-leaf districts, the lands are worth from $50.00 to $500.00 per acre. It is also to be noted that they require every year an expenditure of five to ten times the price of Florida tobacco lands for manures. Moreover the labor and lumber are also correspondingly high, while the value of the leaf is furthermore much lower. So it is apparent that since Florida enjoys all these superior advantages, together with the double advantage of growing two or more crops a year, and immunity from hailstorms, that the inducements presented to engage in the extensive production of cigar-leaf in Florida are unmistakable.

LANDS, LABOR, LUMBER, LIVING.

The best hammock lands in Florida may be bought for $5.00 to $50.00 per acre, according to the proximity of towns and railroads. This amount is about the annual rent of lands in the seed-leaf states, which require also more than double the amount of manures required in Florida.

The cost of living, labor and lumber are correspondingly low in Florida, so that from years of experience it may be safely said that $40.00 to $50.00 per acre should cover the entire cost of crop, which may be sold in the crude state, within one hundred to one hundred and fifty days from the transplanting, or within forty to fifty days from the harvest. So if the yield is from 500 to 1,000 pounds per acre, and the acreage price in the crude unassorted state be 25 cents the average would be 750 pounds at 25 cents; or $187.50. Subtract the cost of labor and fertilizer, $50, and we have $137.50 net profit per acre. While some would fall below this estimate, it should be noted that some have sold this '96 crop at 40 cents to 60 cents average and produced at the rate of 800 to 1,000 pounds per acre. Some have received five hundred dollars per acre, and that in the raw state. It is certain that the finished products would in some rare instances yield even $1,000.00 per acre. While it is possible to increase this return, I will emphasize the fact that many who would attempt it, in a careless manner, would probably fail altogether.

FALL PLANTING.

The advisability of planting a fall crop of tobacco depends not only on the latitude, but on the season; not so much the season for transplanting as for the harvest time and drying, a rainy season or humid atmosphere being more necessary for the latter than the former. The proper time for transplanting a fall crop is August and September, before the summer rains are over; i. e., August for the more northern and September for the more southern portions of the Peninsula. While it might be safe some years to transplant from the last of July to the last of October, re is great risk in transplanting later than September, above 28 degree latitude.

FALL PLANTING OF VUELTA ABAJO.

t may be safely affirmed that the Cuban variety generally planted in Florida, the Vuelta Abajo, will stand a low degree of temperature and even a light frost, if a shower immediately precedes, without serious injury; even if the upper leaves sustain some little injury, they protect the lower ones in a light frost. The Vuelta Abajo is planted in Cuba in mid winter, and therefore it is clear that it is not so tropical and tender as the Sumatra, which comes from the equator.

FALL PLANTING OF SUMATRA.

I am not yet prepared to advise to plant Sumatra at all in the fall, as it prefers the hot sun of mid-summer. Though it may be found when the Sumatra has been acclimated, that it may be planted in fall also.

SCAFFOLDING.

Before the tobacco is brought into the barn it should remain on a scaffold, extemporized of forked limbs of trees and long poles, so as to be thoroughly wilted; for if taken in the house before, and a rainy spell set in and the plant or leaf on the "barn-strut" it will be necessary to put it out into the sun to wilt it down thoroughly, otherwise it will be liable to stem-rot, mould and pole-burn, and will not be as bright, tough and elastic as it should. The scaffold, however, may not be necessary if the weather is bright, warm and dry, so as to insure perfect wilting, which, let it be noted, may be excessive in very hot and dry weather.

FREEDOM FROM INSECTS IN THE FALL.

Another great advantage in fall planting, particularly afte the full moon of September, is that the horned worm and all other pests which cost so much to fight in the spring crop, have gone into their winter quarters, and moreover the summer gras and weeds, having sown their seeds for the next summer's cro are out of the way, and therefore much plowing and hoeing unnecessary in cultivation, for too constant and deep plowing, hoeing and root pruning produce a thick, coarse leaf. Still another great advantage,—the weather is so much more pleasant and therefore the labor less exhaustive.

WEATHER IN FALL.

And if against all this it is argued that the fall rains are uncertain, it can be as truthfully replied that the dry seasons preceding the inevitable summer rains (which begin generally about the 10th to 15th of June and continue for about ninety to one hundred days) are probably as much to be expected as the fall drouth that often follows the rains of summer. And moreover every Florida farmer and gardener knows that less than one half the rain is required for fall and winter crops as for summer, for the nights are growing longer in the fall, and the temperature lower, so that evaporation is much less.

CURING THE FALL PRODUCT.

While there is only one serious disadvantage in planting a fall crop of Vuelta Abajo, there are several compensating advantages which may more than counter-balance. The present fall has been unusually warm and seasonable. The Florida falls are often very dry, succeeding the invariable rainy season of summer. When this is the case I have noted that tobacco though cut ripe will not "cure down" to the sere and brown, but the dry hot winds soon crisp up the leaf in a day or two, leaving the color green; whereas if the atmosphere had been humid and the leaf kept pliant and the coloring matter fluid and flowing, the leaf would take its natural course, which is to color slowly from en to yellow and from yellow to brown. This difficulty may obviated, however, by extemporizing a small furnace for a ge kettle or boiler, like a common sugar-kettle, on the outside the barn, with a wooden top through which an inch pipe may assed into the barn, so the steam may escape under the to- during the dry heat of the day, thereby keeping the atmosphere of the closed barn sufficiently humid. If the barn be made quite air-tight, so that the closed windows, doors and ventilators may prevent the escape of any moisture evaporating from the green tobacco, this will sometimes be sufficient to keep the leaves pliant, in which case the steam is not required. This is far better when practicable. Those who contemplate fall planting should by all means build their barns so as to control the temperature, moisture and light. In fact it is advisable to have all barns so constructed, for if the tobacco could be made to reabsorb its own vaporous moisture and odor as they escape by evaporation, the quality of leaf would be greatly improved in every respect.

EXPERIENCE IN FALL OF 1896.

Again the experiments made this fall in Marion, Pasco, Sumter, Polk and other southern counties, notably by Dr. Corrigan at St. Leo, in Pasco county; by the Cuban Tobacco Growers' Company, at Ft. Meade, in Polk county; and by Mr. Madero near Ocala, in Marion county, where in all, I saw nearly one hundred acres in the fields in the middle of December, without grass or grasshoppers or other pests, fully demonstrate the feasibility of fall planting, at least when the season is so favorable as it has been this fall. While on the Cuban plantations near Ft. Meade the expensive irrigation plant would have insured a crop in a dry fall, all the crops in the various counties were equally promising without irrigation. How far north and west in Florida this can be done may be suggested by the November and December frost-line. From Lake City to Manatee no frost has occurred up to this date, 15th of December, 1896; while west of th Suwanee several frosts have occured. Frost frequently do occur the last of November, even as far south as Tampa, b which time August and September plantings should be safel housed; though I have frequently made cuttings in December a Lake City, (one on the 25th), when the plants had protecti from overshadowing trees. In 1888 I saw some fine tobacco at Ocala by some Cubans on the 8th of April, which had been transplanted in an orange grove in mid-winter. These notes and observations have been made for the benefit of the multitude of tobacco growers, in this and other states, who flood me with letters of inquiry, as well as for those who I suspect will be surprised to learn the facts above set forth.

There is no doubt that where fall and winter gardening is practicable, Cuban tobacco may as safely be risked, if transplanted about the termination of the rainy season as above directed. But it will, as in all the tobacco growing states, be liable sometimes to be injured by frosts.

BRIGHT PLUG WRAPPER.

Mr. Geo. W. Saxon, of Tallahassee, is the pioneer in demonstrating Florida's possibilities in the production of Bright Plug Tobacco. He has for two years past demonstrated that a leaf very like to that grown in the Carolinas and Virginia can be raised on the red clay, and sandy loam soils with clay substratum, of Florida. And the prices obtained in the North Carolina markets compared favorably with the Carolina product. But the distance to a market for this variety, and the fact that nearly five hundred million pounds of plug leaf is produced in the United States, and only one million pounds Florida cigar-leaf, and the fact that the production of the latter is so much less expensive and more profitable have led Mr. Saxon for the present to abandon the idea of growing plug-leaf. He will plant instead Vuelta Abajo and Sumatra on a large scale. Surely he is wise to make this change, since plug-tobacco may be and is grown in several of the states, while there is but one Florida with her semi-tropical climate, and sandy loam soil, and water environment, and ten thousand lakes, and invariable rainy seasons, all conducing to make Florida the coming Cuba and Sumatra for the nerican, and possibly for foreign markets, since the last Sutra crop was a failure, and the Cuban supply was completely off.

SOUTH FLORIDA.

Florida has an immense area that was not penetrated by railroads till within the past decade, and even now the roads are few. As a tobacco growing country it is surely coming to the front. The large bodies of gray hammock lands in Alachua, Levy, Marion, Pasco, Sumter, Hillsborough, Hernando, Lake and Orange counties, and no doubt others that I could not reach, have been tried this year, and some in former years, and have not been found wanting. I have seen samples of Sumatra and Vuelta Abajo and Old Florida Speckled Wrapper, grown by beginners in the southern counties, that have not been excelled by the experienced growers of Gadsden, Leon, Waukulla, Jefferson, Madison and Columbia; and the prices obtained prove the correctness and this declaration.

WESTERN FLORIDA.

In Liberty and Calhoun and in the Holmes valley in South Washington and Walton counties, as well as in some hammocks in Escambia, I have seen samples indicating that the natural conditions are all right, and nothing is wanting but capital, skill and enterprise to develop an industry in every county in the state, provided the lands are selected with judgment: the tertiary limestones and clay surface avoided. This area will supply the twenty-five or thirty million pounds now being imported at a cost of thirty to forty million dollars. But in Florida, as everywhere else, very many of the lands are not so well adapted as others. Even on the same farms some fields are not suited as well as others. Even in Cuba and Sumatra the good tobacco districts are very small compared to the whole area of the islands blessed with the same climate. In fact fine tobacco is exported only from the Vuelta Abajo and Mancaraugua districts of Cuba, both in the Pinar Del Rio Valley. In the Island of Sumatra it is only in the small Delhi district that types of cigar-leaf can be grown fit for export.

GOOD TOBACCO LANDS IN ALL PARTS OF FLORIDA.

But it may be affirmed that as the Peninsula of Florida is more uniform than Cuba, Sumatra or any other tobacco growing state, there are relatively more good tobacco lands on her sandy surface of marine alluvial deposits than in any other quarter of the globe. They are mostly in their virgin state. In many places these lands are as cheap as dirt. The clearing of them is not more, not even so much, as the cost of the annual supplies of manures applied to the old lands of the older tobacco states. It is conceded that the leaf product of well-drained virgin soil in Florida is far superior for several years to that of old fields, artificially enriched. As the virgin soil produces the highest grade of leaf, all efforts to enrich artficially should be with the aim to restore the original and natural properties and physical conditions of the virgin soil of the forests, which have been mulched for ages with fallen foliage. This remark does not apply to swamps, marshes and muck-beds.

CUBAN METHODS AT FT. MEADE.

In company with Col. Henry Curtis, agricultural agent of the F. C. & P. railroad, I made an investigation of the Cuban methods on their extensive plantations, at Ft. Meade, Polk county. On the 15th of December, 1896, we saw no less than 75 acres in the fields in perfect condition, most of it being harvested, while, as an experiment, some was being transplanted, all just as they do in Cuba now, and have done for a century past.

That they have produced and finished a product fully equal to the Cuban in every respect, no one from Cuba or elsewhere has yet been found to question. And when the intelligent president of the company, Dr. M. A. Abelo, told us that the clmate, nd seasons of Florida are all preeminently adapted to the ction of the Vuelta Abajo tobacco, and moreover that they plant eight months in Florida, whereas in Cuba the seed are in August, transplanting is done in early winter, and harvesting in late winter or early spring. He also stated to us that the soil in Florida is not so much worn as in Cuba, where the lands have been "run" for centuries, hence less fertilizer is required here. This company employs Cubans by the score, at $1.00 per day, and every thing is done by hand. No teams, no cultivating with a plow, no hauling done, so jealous are they of every plant and leaf. This of course increases the cost of production to 35 cents or 40 cents per pound, as the president of the company stated, and which we argued could be reduced to 10 cents per pound by the use of improved implements and labor-saving machinery. But when we consider that all their labor is skilled and faithful, and expert in the Cuban method of cutting, curing and baling, and the fancy prices they are sure to obtain, the net profits for their finished goods, either in cigars or bales ready for the "bench," will no doubt pay a good dividend.

At any rate, if they can produce as good a leaf in Florida as in Cuba, which they are confident has been demonstrated, the difference in the matter of duty on the imported leaf alone amounts to a large profit. And when they learn the improved American methods of cultivation in the use of the plow, the sweep, and particularly the horse-hoe, as we tried to show them, one man and mule can care for as many acres as ten men by hand,—a saving of about 80 per cent in cost of cultivation. Moreover the Cuban method of fertilizing and feeding the plant is the same it was one hundred years ago or longer. It seems at least probable that if all the European nations and America have made progress in agriculture, there may be room also for improvement in their ancient though measurably successful manner of fertilizing, which consists in the exclusive use of Peruvian guano which does not combine the proper and preponderant proportion of potash, nor the well balanced proportions of nitrogen, phosphoric acid and magnesia. The same may be said of the prevailing custom of the Gadsden and Leon county growers in the exclusive use of cotton-seed, (sometimes composted wit barn-yard and stable manures), for it has been demonstrated many of the most progressive Experiment Stations and Farm ers' Institutes that no less than one hundred and fifty to two hundred pounds of potash per acre is necessary to secure the best results; and as there is not more than an average of one and a half per cent available potash from cotton seed, to secure a sufficiency from this source entirely too much nitrogen as well as too much money must be applied. If a ton of cotton seed contains even thirty pounds of potash, five tons are required to get one hundred and fifty pounds, the minimum amount required. And yet there is no doubt that cotton-seed either rotted or ground, is valuable if properly combined with potash, (the low grade sulphate), and other essential elements so as to be well balanced, as set forth in former pages.

So upon the whole it will be apparent that we do not presume to make any suggestions on the "Cuban Methods" further than the use of labor saving implements in field culture, and feeding the plant. And there is no doubt while Americans may learn much from Cubans of their barn manipulations, the Cubans will also learn, as all nations have, that America is always ahead in the open-field; that the hoe and the spade have had their day; and that they who would reap at low cost must use the mule and the plow, the harrow and the sweep.

SUGGESTIONS.

BY O. CLUTE.

Many correspondents write me in regard to tobacco growing, and topics connected therewith. I hope that their questions in the main are answered in this bulletin. In order to save the asking and the answering of questions I will say here that the Experiment Station has no tobacco seed to give away or to sell. As there are parties in the state who furnish seed I have not entered upon this work. The F. C. & P. railroad has furnished a good deal of seed free, as have the J. T. & K. W., the East coast, and the Plant System. Perhaps by addressing the officials of the roads seed can be secured now.

Pure imported Vuelta Abajo seed can be bought of the Cuban Tobacco Growers' Association, Fort Meade, Fla., for 25 cents an ounce. It is claimed by some that the tobacco grown the first year in Florida from imported Vuelta Abajo seed is not as good as that grown from seed of the Vuelta Abajo which has been grown in Florida for one or more years. Of this I cannot speak from experience, but I know that the Cuban to- growers atFort Meade had a remarkably fine crop grown from imported seed.

erican grown Sumatra seed can be obtained of the Owl any, Quincy, Fla. It is believed by many that the rown Sumatra seed produces a finer and better fla- than the imported Sumatra seed. Certainly the

Owl Company has had most encouraging success with home-grown seed.

Correspondents often ask about fertilizers for tobacco. On this head, in addition to what Mr. Moodie says in the body of the bulletin, I would say that commercial fertilizers are widely and successfully used for the growth of tobacco. The composition of the fertilizer and the amount to apply per acre can hardly be given in exact terms unless one knows the character of the soil and the uses to which it has been previously put. In order to aid inquirers as much as possible an expert chemist and practical agriculturist has prepared for me the formula given below. The ingredients mentioned can be bought from all dealers in fertilizers. The mixing should be done on a dry floor a few days before the fertilizer is used.

FERTILIZER MIXTURE TO BE APPLIED, PER ACRE IN TOBACCO GROWING, TO LIGHT, SANDY SOILS, HAVING A FAIR SUPPLY OF HUMUS.

250 pounds acid phosphate (12 per cent).
250 pounds high-grade sulphate of potash.
400 pounds cotton seed meal (decorticated).

This mixture should analyze approximately as follows:

Phosphoric acid, 4.70 per cent.
Potash, 14.70 per cent.
Nitrogen, 3.20 per cent.

If it is desired to prepare a ton of the above mixture, use the quantities of the several materials employed, designated below:

555 pounds acid phosphate (12 per cent).
555 pounds high grade sulphate of potash.
890 pounds cotton seed meal.

2000 pounds.

When soils are known to be deficient in humus, as a of long and continued cultivation, without receiving proper fertilizer treatment, the quantity of cotton seed meal recommended above to be applied, per acre, may be increased from one-fourth to one-half. Where fresh hammock soils are to be employed in growing tobacco, the quantity of nitrogen recommended above may be reduced one-half and can best be applied in the forms either of nitrate of soda, or sulphate of ammonia, as a substitute for the cotton seed meal. Where this change is made, employ about 180 pounds per acre, of the former, 145 of the latter.

BULLETIN NO. 39. JULY, 1897

FLORIDA
Agricultural Experiment
STATION.

Strawberry Culture

—FOR THE—

MARKET AND THE HOME.

—BY—

S. POWERS.

The Bulletins of this Station will be sent Free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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STRAWBERRY CULTURE

FOR MARKET AND FOR HOME USE.

Strawberries are grown in Florida only to a limited extent for home consumption; they are produced mostly for shipment to Northern markets. Hence there is comparatively little scientific interest attaching to the pursuit with most growers, so far as the discovery of new varieties is concerned, and the development of old varieties to that state of perfection to which Northern growers are stimulated by frequent competitive exhibitions at the fairs. The Florida grower pursues a system of great simplicity in its objects; the two questions of paramount importance with him are, first, to produce a berry that will ship well; second, and depending on the first quality, one that will sell well. But it must not be supposed that the attainment of these ends does not involve questions of complexity and difficulty. There is no other commercial crop grown in the State which requires more skill in producing and more shrewdness in marketing.

CONSIDERATIONS WHICH SHOULD DETERMINE A CHOICE OF THIS PURSUIT.

To the novice contemplating the choice of strawberry culture as a specialty there are certain considerations which should exert a leading influence with him. It is of great importance that he should have enough neighbors engaged in the same pursuit to form a body of shippers sufficient to guarantee good shipping facilities, such as refrigerator cars, boxes, etc., and a substantial recognition by the transportation companies in the shape of a favorable schedule and the provision of an ample supply of cars for the reception and forwarding of the shipments. There should be a telegraph station during the season. This is not of such importance in the matter of market reports, as these sometimes cause a stampede of the shippers to a market reported favorably, causing gluts and low prices. The greatest value of the wire is in securing a prompt supply of refrigerators, ice, etc., at critical times, when a delay of a few hours might involve serious loss.

No indolent or careless man should choose strawberry culture for a vocation. Ordinary farm crops which do not require much expenditure for fertilizers and labor may be cultivated in a slipshod manner and still yield some sort of a living. But the strawberry demands a great deal of painstaking labor—drudgery it would be called by one not in love with his calling—besides a considerable outlay for expensive fertilizers; so that, unless the crop is kept up to a high standard and all the ins and outs of the markets and transportation methods are vigilantly looked after, the result will be failure. Industry, economy and a careful personal attention to a multitude of details are more important than an intimate knowledge of the markets, for it may be set down as axiomatic that good fruit will sell itself.

SOILS.

The best soil for strawberry culture is a good quality of flatwoods, for this plant demands a liberal supply of water and a water-holding capacity of the soil. To this end there should be a subsoil of clay eighteen inches or two feet below the surface. A long gentle slope to the south is the best situation, as the subsoil of clay acts as a roof, conducting the waters of precipitation slowly downward beneath the surface, in a thin sheet along the clay sheet from which it percolates upward by capillary attraction, watering the plant through a drouth by a system of natural subterranean irrigation.

A hammock or a "bayhead" (a cypress swamp) offers the next most favorable conditions, but a soil of nearly pure muck or vegetable detritus, of a fine floury texture, does not resist drouth as well as does the sandy flatwoods soil. Such soils pack together hard, the moisture rapidly evaporates, the customary spring drouth quickly reduces the size of the berries and terminates the harvest before the shipping season is over. If such soils have to be used their texture can be improved by an admixture of sand; five hundred wagon loads per acre, well incorporated with the muck, would work a decided betterment, but the question whether it would pay for the labor would have to be considered. If the grower has good shipping facilities and the other favoring accessories above noted, and a piece of muck a quarter or half a mile from the railroad station, it would pay him to spend a good deal of labor in hauling sand upon it rather than go out two or three miles to find land naturally adapted, and be obliged to wagon his berries that distance over rough roads before they are shipped.

On light sandy soils, where orange culture would prosper, it is an almost hopeless undertaking to plant strawberries. Nothing will warrant the attempt except the possession of facilities for copious irrigation.

IRRIGATION.

The time will probably come, under a higher system of cultivation and improved methods of transportation which will preserve tender, high-grade fruit in transit, when irrigation will be profitable. Under present circumstances it may well be considered problematical in a great majority of cases. An enterprising wide-awake grower will prepare his land early, breaking it up deep and making it fine and firm; set his beds before the end of the summer rainy season, securing deep-grown, powerful plants which will, on suitable soil, go through the severest autumn drouth without detriment, growing right along. In the usual spring drouth judicious irrigation would doubtless increase the size of the berries—not their number—and enhance their market value. But large strong plants on a deep flatwoods soil will endure a drouth surprisingly well; and the reduced yield of the carelessly cultivated plantations will give a higher value to the output of those which were well cared for, nearly, if not quite, counterbalancing the falling-off in quantity. Still, we believe that, even with the abundant though badly distributed rainfall of this State, some inexpensive but effective system of irrigation will eventually be adopted by the best growers.

But care must be taken not to give excessive watering. A certain modicum of moisture in the soil imparts to the berries size, gloss, plumpness and firmness, but too much injures their shipping quality.

VARIETIES.—THE NEWNAN.

The leading varieties cultivated in the State are the Newnan, Hoffman, Cloud, Wilson and Lady Thompson, in the order of their mention. There are probably five times as many Newnans grown as of all the others put together. It is probably not worth while to give a technical description of these varieties since the purpose of this bulletin is to treat them with referenc to their commercial uses. None of them are of first-class quality for the table. Probably the Lady Thompson and the Cloud are the best for this purpose. The Newnan is so inferior for home consumption that, among the numerous luscious varieties grown in the North, it would occupy a position well down toward the bottom of the scale. It is a hard and rather acid berry, especially in the winter and early spring, and at this season it ripens somewhat unevenly, frequently becoming brilliantly sunburned on the upper side, with a glossiness like that of glass, while on the under side it remains green or even almost white. It is the coldness of the ground and the lowness of the sun in the horizon, burning rather than ripening, which causes this unevenness. In May, if the Newnan is allowed to become purple ripe, it is more passable, but still requires generous treatment with sugar.

The Newnan is not as large a berry and not as productive as the Cloud and the Lady Thompson; it is not as handsome as the Hoffman; not as early as the Hoffman and the Lady Thompson; and the plants are not as vigorous growers as either of the two first above mentioned; yet its all-round good qualities make it very popular, especially in North Florida, where it constitutes the bulk of the plantings, though in South Florida it divides popular favor to a somewhat greater extent with other varieties.

OTHER VARIETIES.

The Cloud is a fine large berry, the plant is a vigorous grower and prolific, but it is a pistillate or imperfect bloomer and must be planted in the vicinity of some perfect bloomer. It is customary to set a bed of Clouds and a bed of Newnans in alternation, or Clouds in the middle of the bed and Newnans around the outside. The Cloud is perhaps less hardy to resist drouth than the Newnan, and in ordinary seasons it does not fruit as late. Being a pistillate bloomer and therefore destitute of pollen, it does not suffer from the attacks of the thrips as much as the Newnan, since that insect seems to have a special fondness for feeding on the pollen, stamens and petals of the bloom.

The Hoffman is a long, sharply conical, almost purple, rich-looking berry, usually commanding the highest prices in the market, but deceptive in flavor, not coming up to its promise. It is not as popular in Florida as among the Charleston growers; it requires a rich soil to bring out its beauties to perfection. It does not hold out well against the spring drouth in this State; it falls off, if it does not altogether cease to bear, several days before the shipping season should close. It is well enough to have a few beds of Hoffmans, highly fertilized, to catch the earliest and highest prices.

The Lady Thompson is comparatively a newcomer, but it has scored a few remarkable successes. It is prolific in a high degree and of an agreeable flavor; its greatest fault is its light color. This renders it unpopular in Boston, while in New York and Philadelphia it is said to have secured, for careful growers and shippers, some very flattering returns. It is a fruit for painstaking men; careless growers should let it alone.

DEGENERATION OF STOCK.

The writer does not believe that strawberry plants necessarily deteriorate in the climate of Florida, but that they actually do so in most instances can not be denied. This is chiefly a result of careless pioneer methods of propagation and cultivation. The same plants are generally compelled to produce both fruit and runners, which is very much the same as the treatment accorded by some of the peasants of Europe to their cows, which they require to supply milk and at the same time labor in the furrow. It is true that in a state of nature the strawberry plant propagates itself by both methods—by seed and by runners, and in a wild condition it probably does not strain itself by so doing. But in a cultivated state it must be remembered that the fruiting aptitude has been enormously stimulated, even to such an extent that plants sometimes kill themselves in a single season by their excessive fruitfulness, and that too when they are not allowed to produce runners.

MAINTAINING THE VITALITY.

It has been repeatedly demonstrated in Florida that, by careful management, the vitality of plants may be maintained at a high standard through several seasons and even through successive generations. For instance, if plants are allowed to escape into fallow ground, provided it is not too heavily seeded with crab or other grasses, and to run wild for a season or two, it is observed that their runners take on a heightened stamina. They seem to recover some of the freshness and robustness of nature, through the survival of the fittest—the weaker ones perishing from neglect. This operation obeys the same laws as those observed by the skillful breeder of live stock, who, however pampered, housed and blanketed he may keep his show animals, allows his breeding herds and flocks to run afield, "roughing it" more or less, whereby, though their coats may become somewhat shaggy, they acquire the ruddy skins and the robust muscles of perfect health.

It is a matter of great importance not to cultivate strawberries year after year on the same land until it becomes "strawberry sick." This is one of the most fruitful causes of the degeneration and "running out" of varieties which we find occurring in the older strawberry sections of the State.

ANOTHER METHOD.

The vitality of plants may be preserved much longer than it generally is, perhaps indefinitely, if they are well cultivated and fertilized and not allowed to produce fruit. To this end the blossoms or the young fruits should be systematically pulled off, and the earlier in their development the better. The formation of seed is the highest function of fruit production, it makes a heavier demand on the vitality of the plant than anything else connected with its growth and development; hence if every flower is pulled off as soon as it appears or even before it opens, the plant will have a reserve of life force to bestow upon its successors, the runners. It will augment still more this reserve if the runners are not permitted to spin out too long. They should be clipped off after they have taken root five or six times. Each plant in succession, as we recede from the parent stock, is weaker and more spindling.

IMPORTING PLANTS FROM NORTHERN LATITUDES.

In the several ways above mentioned the stamina of the plants might be preserved, perhaps indefinitely, but, unfortunately, few growers have yet been discovered in Florida who will take the necessary pains. In the first place, it requires a resolute man to pluck off and throw away fruit when he has been waiting for a whole year for something to pay his store bills with, and that too at a season of the year when fruit is generally bringing fancy prices. During the shipping season the growers are busy and excited over the kaleidoscopic changes in market prices, and few can be found willing to bring their minds down to the prosaic labor of cultivating plants. After the shipping season is over, everybody is exhausted, and it is only a very energetic man who is willing to resume at once the treadmill routine which, to insure success, must continue practically the year round. The rush of the strawberry shipping season is feverish, its fascinations are great, and this same cause which makes strawberry specialists poor and infrequent growers of general garden and field crops also has the effect of making them neglectful of the plants at this time except to strip them as rapidly as possible of their money-yielding berries.

Hence when planting time approaches many growers find themselves with badly depleted beds, hundreds, perhaps thousands of plants dead. Their best resource, then, if within their reach, is to send to a more northerly situation for a fresh stock, for it is the case with strawberries as with Irish potatoes that a resort to higher latitudes for seed secures a fresh infusion of vitality. It is not necessary to go any further north than the piedmont region, or the extreme lower foothills of Alabama ro Georgia, where the clay of the flanks of the Appalachian chain breaks down into the vast wire-grass flats of the coast region. And it is highly probable that the advantage gained here arises more from the clay soil, with its greater natural supplies of potash, than from the inconsiderable difference in latitude between North Florida, for instance, and the region directly north of Mobile. A still more marked advantage is gained by importing plants from the piedmont regions of North Carolina; for in this case there is not only a better soil but an important gain in latitude.

That the higher latitude is not the principal element of superiority in northern regions is proven by the fact that strawberry plants imported from States north of the Potomac and the Ohio are almost universally a failure in Florida. The simple fact is, take the Newnan or any other variety acclimated in Florida, carry it up to the edge of the clay foothills and grow it there even one year, then return it to Florida and it will be found to have received an important accession of vigor.

TO PRESERVE OLD PLANTS THROUGH THE SUMMER.

In some instances it is worth while to preserve through the summer, plants which have fruited once; in other cases it is not. In another paragraph the importance of bringing plants from a more northerly section was explained, it is there shown that it is unprofitable to cultivate continuously the plants grown in Florida. The considerations there given will decide the planter whether or not to hold his stock over and fruit it another year.

If he decides to do so, very soon after the picking season is ended the mulching should be raked off and the beds should be hoed out. Leave all the trash lying where it grew, and if there is not enough of it to shade the ground, throw back some of the mulching.

As the strawberry plant practically grows all winter in Florida, it must have a season of rest sometime during the year. That season is in midsummer. It does not want to be cultivated then; it ought to be let alone and allowed to lie dormant. At this time the life of the plant retreats into the central bulb. All its roots die and turn black. Only a thin and feeble plume of leaves remains to show that there is any life left in the plant at all. In this puny condition one can often kick out with the toe of one's shoe, what in the spring was a vigorous plant firmly anchored to the ground and yielding a good crop of berries.

At this time therefore, it does not need to be cultivated, because cultivation would keep it in a state of semi-activity, dragging along through the "rainy season" and emerging in the fall with a spent vitality, unable to recover itself and produce a good crop. The hoeing above mentioned is not to constitute a cultivation but a simple scalping of the ground, cutting off the weeds at the surface. The nearer the plant can be allowed to lapse into a condition of perfect dormancy, the better it will be for it in the fall. Plants cultivated all summer will give a delusive promise in autumn, only to break down completely when the fruiting season arrives.

In this feeble condition it requires protection from the sun. If mulching can be retained on the ground without breeding destructive vermin, this will be a help; it keeps the ground cool. If mulching is out of the question it is better to let the weeds and grass grow to some extent. Of course, the crabgrass can not be allowed to have its own way unchecked, or else it will speedily smother to death the enfeebled plants. These must have access to the sun but they want a modified sunlight. A thin row of corn about every four feet or one of rice every three feet will help to protect the strawberry plants. But these protectors must be removed gradually in the fall, or else the sudden change will destroy the plants. The writer has seen a hedge of dog-fennel growing in the dead furrow between the beds preserve in good condition the plants as far out as the shade extended, while those left to the tender mercies of the crab grass perished. A neat farmer would condemn these hedges of dog-fennel as slovenly, but he might do worse than by tolerating them.

Running through the rows once in three or four weeks, with a Cole garden sweep, roughly scalping and cutting the thickest patches of grass, is advisable. But let everything be done without stirring the soil.

IN LIGHT SOILS.

There may be cases where strawberry culture would pay for a home supply, on soils so light and sandy that it would be well nigh, if not quite, impossible to preserve plants alive during the summer. The bearing season is so long in Florida and the value of a supply of fresh berries for the table every day in the late winter and spring is so great, both from an economic and a hygienic standpoint, that the grower could afford to purchase a few hundred plants afresh every fall. But we doubt whether strawberry culture for commercial purposes would pay on soils so light that the plants would wholly perish every summer.

RAISING RUNNERS.

The greatest enemy to strawberry plants in this State is the crab grass, and this also interposes the most serious difficulty which is encountered in raising runners. For this purpose it is best to select a piece of land which has not been long enough under cultivation to become seeded to crab grass. A piece of wire grass sod, just inverted, would afford perfect exemption from this pest, but, unfortunately, the strawberry will not vine well on raw land. It will throw out runners to some extent if the sod is well treated with quick lime or fresh hardwood ashes; still it is generally advisable to plant land which has been a year or two in cultivation, even though it may have a little crab grass.

For the propagation of runners it is advisable to set the parent plants as early as March or even February. The ground is then cool, very few perish, they take root and grow off rapidly. Runner plants formed in the spring or early summer may be allowed to stand a month or two; they thereby mature and their roots lose their white, fresh appearance and that tenderness which makes them so perishable when transplanted. The novice will generally reject these dark-rooted plants as being too old, and eagerly purchase the white-rooted ones; but unless he is prepared to remove them with earth on or to shade and water them with assiduous care, he will make a mistake in this selection. The dark-rooted plants will live when others will die.

The method of bedding is elsewhere described. Run out a furrow wth a hand-plow, strew in it a mixture of four parts cotton seed meal (by weight) with one part fifty-per-cent sulphate of potash at the rate of five or six hundred pounds per acre. Run another furrow close alongside covering up the fertilizer and set the plants in this last furrow. Firm the earth well around them with the feet as a protection against the customary spring drouth. As soon as they are established and begin to grow, run around them with a garden sweep (Cole's is best), carefully pick out all weeds lurking around them and lightly hoe. In a week or ten days, unless it is very dry and threatening drouth, plow deep and close to the plants. The deepest stirring should be the first, before roots have been formed; then go shallower each cultivation as the surface feeders are thrown out. Always weed thoroughly; turn up the leaves and pull out all sneaking intruders. If allowed to remain and grow until they reveal their presence above the plants, they disturb the latter more when pulled out and they bring away with them a quantity of fertilizer which they have stolen—a clear waste.

After the last cultivation has been given the runners should be straightened out and distributed around over the ground so that, as they take root, the young plants shall not be crowded together in bunches.

Where old plants are used for the propagation of runners, the fruit should be kept picked off until the end of the bearing season; otherwise it will fall down around the plants, rot and the seeds will spring up, producing seedlings which may be totally unlike the parent plant and worthless.

IF OLD LAND IS USED,

It is best to continue the cultivation of it severely until about the middle of July, regardless of the runners that may start out. By this time most of the crab grass seed which may be in the ground will have germinated and the young grass plants will have been destroyed, so that when the cultivation ceases there will be little left to come up. If the cultivation is discontinued as soon as the runners begin to shoot out, the crab grass will grow so rapidly that it will swamp the young plants unless a large amount of hand-weeding is done. The Planet Jr. cultivator has an adjustable fender which lifts the runners to one side and enables the cultervation to be performed without covering up the ends of them with the furrow-slice.

It is very important to stir the ground deeply in which plants are to be grown, and this is especially the case when it has been compacted by the repeated tramping of the pickers. If the ground is left hard the tender, white rootlets of the young plants can not penetrate it to any depth; they spread out near the surface, stunted and feeble; and, even if the plants acquire sufficient volume to promise well, they are very unsatisfactory because their roots are so short that they quickly dry out and die when transplanted. On the other hand if the ground is kept mellow the roots run down long and vigorous and such plants can be set with much more confidence that they will survive.

It is very essential also to keep the grass and weeds subdued on the runner-bed, for if the young plants are compelled to grow up tall and spindling to reach the sunlight they are tender when transplanted; they fall over helpless, do not shade and keep the ground cool around their own roots, and quickly perish.

Plants grown on clean land are short, stocky and vigorous.

DIGGING AND SHIPPING PLANTS.

As much of this is done in the heat of the summer it is necessary to handle and pack the plants very carefully or they will either dry out or else become heated and spoiled. To dig them strike a prong-hoe into the ground as deep as the roots extend, pry and loosen it up. Pull them out without breaking the roots unnecessarily, pinch off all runners which are over three or four inches long, plunge them into a bucket of water and place them at once in the shade. Have a box with a saw-cut in each end deep enough to hold a string, and stretch the string across about three inches from the side of the box. Lay the dampened plants across the string with their roots against the side of the box; this will give the bunches a neat, even appearance. Tie them into bunches of 50, 100 or 200, according to their size. In coolish weather they may be shipped safely in a box just deep enough to receive the bunches placed on end, standing on a generous layer of dampened sphagnum moss. Crowd them in as tight as they can possibly be crowded, to prevent drying out, then nail slats across the top of the box, with spaces of an inch between them to give ventilation.

If the weather is dry and hot and the distance is considerable greater precautions must be observed. Pack the bunches in a barrel, a half-barrel or a box, laying them on their sides with the roots inside. Have a log or a section of stove pipe extending down through the middle of the package. When the box or barrel is full, withdraw the stove pipe and cram the space which it occupied full of dampened moss. The package may then be closed up tight with the exception of a few auger holes here and there to give ventilation.

TURNING UNDER OLD BEDS.

It is very seldom that it will prove profitable to retain a bed of plants more than two years, though the writer did once keep nearly his entire plantation three years and harvested the third year a heavier crop than in either of the preceding years. But the berries, though in immense numbers in the wide-spreading plants—some of them almost as wide as a straw hat—averaged very small and the losses in sorting were consequently heavy. Subsequent experience has confirmed me in the belief that a careful, energetic grower can turn his beds under every spring and replant them outright in the fall more cheaply than he can fight crab grass all summer, laboriously scrape and pick it out of the beds in the fall and refill the many missing places. To adopt this bold course of turning his beds under every spring, he should make sure of a generous provision of vigorous young plants early in the fall or late summer; then he may do it fearlessly.

Take a three-horse sulky plow of the Canaday or other equally good pattern and with it split each bed in the middle, throwing half of it each way. A good plow man will lay the furrow-slices over one on the other as even and regular as the courses on the side of a weatherboarded house. Sow the beds in cow peas and run over it a few times with a cutaway harrow to cover the peas. If the weather is very dry it is well to roll the ground. A good enough roller can be manufactured by the grower himself from a pine log about eighteen inches in diameter, set in a frame-work with a bench above it on which the driver can ride to give it greater weight.

The attempt to turn under a mass of weeds and grass, mulching and plants with a one-horse plow is one of the most unsatisfactory and exasperating labors on the farm; but with a large heavy plow, as above described, it can be done to perfection. After the cow peas have been removed, split the beds again and reverse them, thus making the dead-furrows or allews where they were before. By this time the mulching and old plants turned under will have mostly rotted and imparted their juices to the soil to benefit the coming strawberry crop.

CLEANING UP OLD BEDS.

Along in the latter part of August in North Florida (a month or six weeks later in South Florida), the grower must decide whether it will be more profitable to clean up his old beds or plow them up and plant anew. This question will be decided by the condition of the old stand and his supply of young plants. If half the plants are dead he had better plow the beds down, first removing the most vigorous of the old plants, to be divided and reset, and the best of the runners. If there is over half a stand, it will probably pay to clean up the beds and refill the missing places.

To do this hoe the grass off at the surface and pull it out of the stools, leaving it to lie where it stood for several days. If removed at once the sun may heat the earth to such a degree as to kill many of the plants. Old plants which are vigorous enough to be worth saving over another year do not require any further cultivation at this time; the simple killing of the grass, giving the plants the benefit of all the sunshine and of the moisture in the soil, will be all they need until October perhaps. But the missing places should be refilled as soon as the beds are raked off.

If there are many thrifty young plants scattered about in the grass it will be worth while to save them, unless the grower has an abundance in his runner-beds. To do this it will be necessary to pull out a good deal of the grass. Shake the earth from it and return it to the ground where it stood. In a week or ten days it may be raked off; the plants will by this time have become accustomed to the change so that they can endure the full sunlight.

PLOWING FOR NEW BEDS.

If new land is chosen, the raw wire grass sod should be broken up the winter before hand, though the plowing may, if necessary, be deferred until the picking season is over, or even to the beginning of the "rainy season," if a good application of lime or potash is made to correct the native acidity of the soil. The plowing should be done with a powerful team, turning the sod over at least eight inches deep, followed by a man with an ax to chop out the roots left in clearing. Native farmers oppose such deep plowing for the first time, on account of the sourness of the sub-soil (and their argument is correct if no application is made to correct this sourness), but the lime removes this objection. Besides that, a considerable depth of loose soil is needed to make a mellow bed, as it is difficult to cut up the tough sod sufficiently fine to receive plants. It is best to bury it deep down and to use no implement in the subsequent cultivation that will bring any pieces of it to the surface.

Plow the sod into beds twelve or fourteen feet wide, slice them very thoroughly with the disc or cutaway harrow, lengthways and crossways. Plow out the dead-furrows a second time and throw the loose earth over the beds to assist in forming a mellow surface. Sow lime over it at the rate of fifteen or twenty barrels to the acre. Caustic lime freshly slacked is better than the air-slacked; stone lime is better than oyster shell lime. This should be done in the rainy season to give the showers an opportunity to wash the lime down and "sweeten" the soil. Then let the beds stand two or three weeks—depending on the amount of rainfall—for if plants are set sooner than that the lime may burn one here and there.

PLOWING UNDER VEGETABLE MATTER.

If old beds are to be plowed, the question arises, How much vegetable matter is it advisable to turn under? We have not space here to enter into a discussion of the humus question in all its bearings. Unquestionably the thin, sandy soils of Florida need decayed vegetable matter or humus, but it is extremely injurious to strawberry plants to set them over a mass of green vegetation, whether cow peas or crab grass, recently plowed under. In fact, this should not be plowed down any time in hot weather, as it sours and deadens the soil for a year or more afterward. (In the spring plowing above described the mulching and the dried up plants are not injurious to the land). Therefore, at the time of the summer or fall plowing, everything on the surface should be mown off close, leaving only a short stubble to be plowed down. We have known a mass of cow peas plowed under to sour the land to such a degree that strawberry plants set over it yielded practically nothing, and it was two years before the land recovered its tone and vigor.

BEDS OR FLAT CULTURE.

Strawberries are grown in Florida by various systems, from a bed containing a single row up to those with eight or ten rows, and without any bedding-up, the flat culture. The adaptability of each system must be determined by the character of the soil. The best strawberry soil is found in a good class of flatwoods; and of this there is a good deal which "runs together" in a rain and dried out with a crust. Such land will produce an excellent crop of berries if it is broken up afresh every fall, and frequently it is almost impossible to secure a good crop from it without. On wide beds in this sort of land one will frequently see the outside row flourishing quite beyond any other one on the bed, notwithstanding the fact that, being on the outside, it receives only half as much fertilizer as the inside rows. This superiority is undoubtedly due to the better drainage and to the consequent light and friable nature of the soil. Indeed, if one of these outside plants is pulled up, it will be found that a large majority of its fine feeding roots are on the bank-slope, growing close to the surface, where they can enjoy the sunshine and not be lacerated by cultivation. In such land therefore a just medium should be observed. If the beds are too wide the water does not run off readily after heavy rains and the inside plants are stunted; if they are too narrow they dry out and it is difficult, in setting plants, to make them live unless the weather is showery.

Narrow beds do not retain mulching well in a high wind. Narrow beds are best in a wet season, in a dry season they suffer most from the drouth. Still, on the whole, it is advisable to plant a few two-row beds to furnish early berries.

All beds should be full in the middle, sloping evenly to the edges so that no water shall collect and stand in hollows. This is a very important item in making the bed. We have known a row midway of one side of the bed, on account of bad drainage, to produce not over fifty per cent as much as an outside row or the one on the central ridge.

On a bed running east and west the side sloping to the south will produce more and earlier berries than the side sloping to the north.

On dry, light lands, especially in South Florida, it is best to pursue the system of flat culture.

MAKING THE BEDS.

Where the plowing was well done, as above described, and the cutaway harrow and roller employed, the amount of handwork required is reduced to a minimum. Still, the grower should walk up and down several times and survey the beds critically, garden rake in hand, to determine the situation of any inequalities and remove them. The beds should lie a week or two, then the rain will settle and firm them and point out unerringly where the hollows are. All roots and sticks should be collected into piles and burned. All pieces of sods should be raked off into the ditch; they interfere with the stretching of the line in setting plants.

MARKING OFF BEDS.

On deep, rich, mellow land, plants may be set in rows 20 to 24 inches apart, and 15 inches in the row; on thinnish land, 18 inches apart and a foot in the rows. Hill culture is universal in

Florida; matted rows, as in the North, could not be managed on account of the prevalence of crab grass. The plants also need to be isolated so that the sun may be able to shine on all sides of them and color the berries, which is not so readily accomplished in March as in June.

For a punch a round pointed wooden stake will answer. If the grower can not judge distances readily by the eye he had better construct a four-pointed punch—the points 12 or 15 inches apart, as desired, and mortised into a bar upon which he can step to thrust them into the ground. The points should be steel, to prevent damp earth from adhering to them; about three inches wide and six inches long, wedge shaped.

For a marker, take four inch-boards about two feet long and six inches wide, shape them like sled-runners and fasten to a frame-work, 18 to 24 inches apart, as desired, to be pushed or pulled by a handle, making slight row marks in which to set the plants. Stretch a line near the outside of the bed and run the marker by this the first time. It is very important to have the rows straight for convenient and rapid cultivation. If the rows are straight a good workman with a neat hand-plow can shave out weeds within an inch of the plants, thereby saving hand weeding.

It is always advisable to lay off a bed in an even number of rows. Pickers like to take two rows at a time, and if there is an odd row they are likely to skip it unless closely watched, and thus berries will be overlooked.

SETTING PLANTS.

The strawberry plant under different weather conditions behaves very differently. In the cool humid atmosphere of a northeaster in September it will live if thrown on the ground. In the dry hot weather of October it will generally die despite all precautions of watering and shading. The conditon of the atmosphere is all-important. It is nearly of equal importance to keep the plants constantly dampened and bunched snugly in a vessel to protect them from the sunshine. When the sun is shining it is a ruinous policy to drop them along the rows and let them lie several minutes before the setters reach them. A better plan is to have a boy insert the roots of the plant in the hole just a few seconds ahead of the setter; or else let the setter keep a vessel of plants before him and help himself to them one at a time.

Some growers think it best to pull the leaves off the plant before setting; others hold the contrary opinion. This is really of much less importance than the condition of the atmosphere and the ground as to humidity. We favor the retention of the leaves, since they shade the ground and thus protect the plant somewhat.

In the cool of the evening is a much better time for setting than the forenoon; then the dew is beginning to fall, the atmosphere is cool and refreshing and the plant has time to recover from the shock before morning. It would, in many cases, pay the grower to employ an extra hand to carry a lantern and set until nine o'clock, rather than have the plants put out at nine o'clock in the forenoon free of charge.

The grower must not allow himself to be deceived even by a daily shower. There are times in July and August when a shower falls nearly every afternoon, yet the forenoons are so hot and dry that fifty to ninety per cent of plants set then will perish inside of ten days. We have thought sometimes that where the strawberry grower is not naturally "weather-wise" it would pay him to keep a hygrometer, an instrument for measuring the moisture in the atmosphere.

It is of the highest importance to have the beds well settled and firm before setting begins, so that, when the holes are punched, the punch will leave a clean-cut, smooth-walled hole and not pull up and loosen the earth. To enable the rootlets of the newly set plant to draw moisture and keep the plant living they must be pressed up against a permanently moist surface. The harder the bed can be rendered the better—provided it was plowed not over a month before—for after the plants become established it can be loosened up again. Hold the roots of the plant against the firmest side of the hole and fill in with moist earth; all dry, crumbly soil should be brushed away and not allowed to fall into the hole. Tamp the earth down solid clear to the bottom of the hole; if an air-hole is left it will dry out and kill the plant. Stamp the surface down with the foot or strike it a smart blow with the fist. To test the work take hold of a leaf and pull; if the plant is properly set the leaf will break off before it will loosen the plant. When the filling in is completed the bud of the plant should be just on a level with the surrounding surface. In a very dry time, however, it is well to set the plants in the bottom of a light furrow made by a hand-plow, though, when a shower comes, it will be necessary to examine the plants to see if any have become sanded, that is, the buds covered with earth.

It is a mistake to have a large quantity of roots on a plant. They make a loose bundle which can not be compressed tight enough to exclude the air and they will dry out; whereas a few long roots, reaching down to permanent moisture, can be so closely packed with earth that they can not dry out but will draw moisture steadily and keep the plant alive.

TIME OF SETTING.

The grower of strawberries for the earliest markets should beware of delay in setting. Better harvest the cow peas or crab grass when half grown, prepare the beds and plant rather than wait for the hay crop to mature and thus have a late stand. A small, thin-foliaged plant, is a very poor piece of property in the spring when frosts are falling. On the contrary, a large, deep-grown, powerful plant, set in July or August and encouraged by constant care and feeding to a steadily progressive, unchecked development, will, in time of frost, protect its fruit as a brooding hen does her chickens. We can not write too emphatically on this subject. The frost will pierce through and through the weak, small plant and freeze every berry, every blossom; while the grand plant, fully matured, will hide away dozens, yes scores, of blooms and berries in its voluminous foliage which the frost will never touch. A certain proportion on the outside may be frosted, but nothing short of a bitter freeze can penetrate its interior. Such are the benefits of early planting.

WATERING AND SHADING.

The best way to water before planting is to punch the holes and fill them with water; when this has soaked away set the plants as above described. Watering strawberry plants newly set in a drouth is generally labor lost, unless there is an irrigation plant, enabling the growers to saturate the ground. It is usually more efficacious to set the plants in the bottom of a slight hand-plow furrow and cover each one with a shingle or a dwarf palmetto leaf, sloping close down over it. A little water applied in a situation like this will help a considerable. Do not pour the water down a foot or two and let it crust and harden the ground; hold the cup clear down to the earth and allow the water to flow out. A crust formed by the beating of a stream of water, unless broken up, will greatly injure the plant, if it does not kill it.

There is nothing in the strawberry industry more unsatisfactory and exasperating than to get a late stand and then to coddle it through the fall drouth, puttering with water and shade and perhaps with pinches of nitrate of soda, and then not see the plants grow a single leaf in a fortnight, perhaps even longer. On the other hand, plants set in July or August and well-rooted before the drouth begins, will grow in the driest, hottest weather, grow in a way which is surprising to the novice. By all means let the grower provide an abundant supply of vigorous plants, with a margin for losses, and then get an early start. (See paragraph on South Florida, further along.)

SETTING OLD PLANTS.

This is to be avoided if possible, but sometimes it is necessary. Vigorous plants not over two years old, if taken up early, divided into fingers, properly prepared and set will frequently fruit about as well as young plants.

Before the new fall growth sets in an old plant is nothing but a bulb; it has no live feeding-roots whatever. This bulb is wrapped up in a quantity of dry, leathery husk. The feeding-roots which start first are white and exceedingly tender and frail. If this old, tough husk is not removed it takes them a long time to penetrate it and reach the earth. Scrape it away with a knife or wring it off with the hand, thoroughly, down to the pink —not into it. These minute, white roots spring close to the surface of the ground, directly below the base of the leaves; hence the cleaning of an inch in length is sufficient. If this husk is not removed the plants will get such a late start that they will not amount to anything.

SETTING PLANTS WITH A TROWEL.

Where the plants do not have to be carried but a few rods and the earth is tenacious, the writer has found it very satisfactory to transplant with a trowel. A careful hand can work at this all day regularly in anything except the very driest, hottest weather. This method is slow but sure. By it large, strong plants can be removed as late as November and still bear a good crop. A nearly flat, wide trowel is better than one deeply dished. Be careful not to break open the balls of earth containing the plants. If the earth is somewhat dry water the bed before taking up the plants.

CULTIVATION.

The first cultivation may be given when the plants have been set about ten days. The flat or weeding hoe is the proper implement. File it up sharp and shave off the grass around the hill very shallow, merely to break the crust. Clean out the middles with a hand-sweep. Keep the sloping edge of the bed unbroken; let the weeds and grass grow there as a retaining wall to prevent the bed from being washed down by heavy rains.

In three weeks the stirring may go as deep as it is intended to go any time during the season; but if the weather is continuously very dry, let the cultivation be shallow, simply enough to stir the surface a half-inch or an inch deep. The "dust-mulch" is the best protection of plants against drouth, that is, a thin carpet of soil kept very finely divided and frequently disturbed and level. In ordinary weather, with seasonable rains, the cultivation may be as deep as a strong man can drive the plow down; but after the first month or so, especially when the cool autumn nights sets in, it should go more shallow each time. In the hot weather of summer the roots go down by instinct in search of moisture; when the nights grow longer and cooler they begin to run nearer the surface to receive the effects of the sunshine. The depth of the stirring should be guaged accordingly.

If the bed has stood over the summer, the first cultivation will be laborious, it will take a strong man and he will have to pass two or three times in each balk to drive the plow down deep enough. For this he should use a bull-tongue. Between the plants in the row the crust will have to be broken up with a prong hoe; it should be struck down its full depth and the crust pried up and mellowed by a stroke or two with the back of the hoe. This is tedious work but it will pay.

Occasionally an enterprising grower breaks up old beds in the fall with a narrow cultivator drawn by a horse. This is a great saving of labor and is advisable where the balks are wide enough to permit it. If the weather is unusually dry great care should be taken not to cultivate so close as to break the old plants loose; it may be well to remove the outside teeth of the cultivator to narrow it down sufficiently.

It will pay to run a sweep or a light hand-rake through the rows every week or ten days, even if there is no trash in sight. It promotes the growth of the plants greatly; it is worth almost as much as a shower.

FERTILIZING.

A good fertilizer is as follows (See formula on last page):

Ammonia	2 to 4 per cent.
Phosphoric acid	7 to 9 per cent.
Potash	10 to 12 per cent.

We would have no cotton seed meal in it, or, at any rate, the less of it the better. Some growers argue that cotton seed meal will answer every purpose as an autumn application merely to make growth. We object to it even for this purpose. It will produce beautiful foliage and an abundance of it, but next spring it will be found that the foliage is out of proportion to the fruitage. The fruit will be short-stemmed, lurking down among the leaves, and will never color up properly. The mineral fertilizers are better in every respect. No animal manure, unless it has been rotted at least a year, should be applied to strawberries that have to be shipped a thousand miles; they will be too soft to stand the ordeal. And, for the same reason, nitrate of soda should not be applied to them for three months before shipping begins.

The judicious grower will keep before him as his great object in fertilizing to feed the plant progressively, never to let it come to the end of its supply and begin to retrograde. In the thin soils of Florida the strawberry plant lives on the farmer; it depends on his fertilizer sack as absolutely as the pig confined in a pen depends on the grain sack. If it is fed liberally in the late summer or early fall and makes a vigorous growth, exhausting its supply of nourishment, or some element of it, it will go back; "dieback" will set in. It is simply an indication of famine, and prevention is tenfold better than cure.

In most old soils there is sufficient remnant of fertility to carry the young plant along a month or six weeks; then it will need feeding. Run a light furrow with a hand-plow, about two inches from the plants, strew in a complete fertilizer at the rate of about 400 pounds per acre and cover it with a return furrow. It is a good plan to make the first application on the outside or the inside of each row, running the plow down one side of the bed and up the other. Then, a month or so later, make the second application on the opposite side from the first application. Then make the third and last one, in November or December, directly between the plants in the row. Let this be the main application; it is in mellow ground where the pickers will not tramp and the roots will feed on it all through the fruiting season. It can be put in rapidly by three men. One stroke of a hoe makes the hole, the fertilizer is dropped in—not in a bunch but scattered—a second stroke pulls the earth back. It gives the plants a cultivation at the same time. First application, 400 pounds per acre; second, 600; third and last, 1,000; total, one ton per acre. It is not too much, if the grower is a good manager otherwise—if he is not, he would better let strawberries alone anyhow. The writer has applied two tons per acre and believed that the last half ton paid nearly as well as the first ton and a half.

HOME-MIXED FERTILIZERS.

There is no doubt that the farmer can save a few dollars by purchasing the ingredients and mixing them himself. Among our acquaintances there are a few who pursue this policy, but they are not generally as successful as some others who buy ready-mixed fertilizers. This does not prove that the home-mixing policy is necessarily a mistake—though we think it is generally—it simply shows that this class of growers are usually men of extreme views in some directon and they do not supply the plants with a complete fertilizer, one containing all the elements they require in the proper proportions. A mixture of bone and ashes is a favorite with some of these growers. It does not usually give the highest results; it is not a complete fertilizer; it contains little or no nitrogen. Plants are like animals in one respect; they thrive best on a variety of feed. A fertilizer which draws each of its three principal elements from several different sources generally gives the best results. For instance, nitrogen derived from nitrate of soda, sulphate of ammonia, blood and tankage is generally more acceptable to the plants than nitrogen supplied from either of these sources alone.

CUTTING RUNNERS.

The runner always detracts from the fruiting capacity of a plant and is to be removed before it acquires any length. A plant which is allowed to put forth runners at pleasure will produce as many berries next spring as if it had not borne the runners, but they will be so small that there will be a heavy loss in sorting. The gain in runners will be counterbalanced, and more, by the loss in berries of a merchantable size. The best way to remove runners is to hire a small boy with his own knife, and we say this advisedly, for he will lose knives about as fast as you provide them. We have tried various implements for clipping off runners, but found nothing equal to hand-cutting.

MULCHING.

The best available material for this purpose is wire grass hay; it is free from seed of all descriptions, soft, tough and durable. In the flat woods it can be cut with a mowing machine at the rate of several tons a day. Generally about a ton per acre is required to properly mulch the plants. Pine straw is the next best material; it is, however, objectionable because of its resinous quality and dark color, which cause it to absorb the sun heat and reflect it in the faces of the pickers. Its sharp points warp up and prick their knees.

The mulching is carried out on slatted straw carriers and sprinkled evenly over the beds, hiding the plants from sight. In two or three days it settles and reveals the outlines of the plants; experienced hands go on their knees and with a quick, circular motion pull the plant through and at the time tuck the mulching under all around.

Energetic growers like to apply their mulching about January 1, thereby getting rid of further cultivation and securing a rest before picking begins. But it has been discovered that a later application is better in several respects. In the winter the plants need the sunshine, and if this is suddenly cut off by the application of mulching and a cold rain falls, the plants are apt to experience a check in growth and suffer from rust. Where the mulching is put on early the winter weeds grow up through it and become troublesome before the end of the picking season; whereas, if the mulch is kept off later, a final light hoeing will destroy these weeds. Lastly, the naked ground affords no small protection against frost. Berries lying on the ground will escape the frost while those near by lying on the mulching will be frozen to the centers.

Some growers think that if the mulching is applied after blooming sets in, the plants are knocked about and some of the pollen is lost. Probably this objection does not amount to much. But it is certain that, where the mulching is put on late in the winter, it should not be left long; all the plants covered during the day should be pulled through before night. (See paragraph on South Florida).

INSECTS.

In some sections the white or cotton cricket gives considerable trouble. It cuts off the leaves and drags parts of them down into its burrow, being a subterranean dweller. The best remedy is to heat a kettle of water near by and pour a teacupful boiling hot down the burrow.

The white grub is remediless. It gives no indication of its presence until the plant is seen to wither and die, when an examination shows that it is cut in two near the surface. Grubs are generally worse in sod land or in old land which has lain in grass awhile; after two or three years cultivation they disappear. Good strawberry land may be profitably kept in cultivation year after year, thus measurably escaping grubs, white crickets and cut worms. It will pay to fertilize a little extra with this in view, but to observe a rotaton of crops.

Against cut worms the best defense is hand-picking. Employ children and pay them a few pennies per pint or quart. Poisoning with a mixture of wheat bran, water, Paris green and molasses enough to make it sweetish is said to be efficacious; we have never given it a trial. Larks, quails and kildees, if not disturbed, will probe the earth with their bills and catch a good many. It is a mistake to kill these birds, even in the fruiting season; they may be frightened away by the discharge of a shotgun.

The thrips, in an occasional season, say once in six or eight years perhaps, does much damage by destroying the pollen and petals and even scattered pips of the berry, causing it to grow misshapen and dwarfed. It is an insect of a clear honey-yellow, about a sixteenth of an inch long, with rudimentary wings. Its presence is not generally detected until the blossoms are noticed to be turning brown prematurely, and by this time it is usually too late to combat it to much purpose, as the mischief is already done. If detected in time it may be destroyed by a moderately strong solution of whale-oil soap, one pound to four or five gallons of water if thrown upon the flowers in fine spray. Applications of pyrethrum will also effectually reduce their numbers, says Professor H. G. Hubbard. They seem to be most abundant after a mild open winter, and in such seasons it is well to be on the lookout for them early. A few are always present in the blossoms in spring and need not constitute a ground of alarm. Pistillate plants like the Cloud are mostly exempt from their attacks, on account of their scarcity of pollen; he is fortunate who has a strong contingent of this variety in a thrips-producing season.

It is an invaluable measure of defense against insects of all kinds to have the plants large and vigorous. Prevention and protection are always better than cure.

DISEASES—RUST.

"Strawberry rust" is more correctly designated as leaf-spot; it consists of small brown spots with white centers, which gradually increase in numbers until they nearly run together and so kill the leaf. These spots are caused by a destructive spore or vegetable fungus which fastens itself to the leaf and feeds on its tissue, spreading its roots out in every direction. It is not a constitutional or sap disease; it is not propagated within the plant itself but from without. These spores or disease germs are borne through the air by various instrumentalities, and a plant containing them on its leaves becomes a center of infection to all its neighbors. Various sprays are recommended for the cure of this disease, but we have always believed general treatment of the plant more effective than local treatment and have never applied them.

Leaf spot generally strikes plants which have been making a rapid growth and are accordingly soft and succulent, and then from any cause receive a check. Thus a long, cold rain or the sudden application of mulching, thus cutting off the sunshine from the ground when they are growing, are frequent causes of "rust." When these causes are removed good strong plants will generally "grow out of it" in a few weeks. They need to be stimulated with fertilizer and cultivation, if not too late in the season for the latter. If most of the diseased leaves are picked off and burned, it will assist the plants in throwing off the parasites. Strong, well-nourished plants seldom succumb to the disease; it is an accompaniment of weakness. It is important to be certain that the leaves are free from the parasites when the plants are set: then by maintaining a steady, progressive growth, never too rank, never falling back, the grower can carry his crop along without fear of injury from this source.

DIEBACK OR WHITE BUD.

This is produced by conditions similar to those which cause leaf spot, but more particularly by over-feeding and a consequent lush growth in the hot weather, followed by a letting-down when cooler weather supervenes. Dieback is simply starvation, a pining away for lack of one or more elements of fertility—in most cases, potash.

It is important to the grower to be able to detect the earliest symptoms of this disease, in order that he may be ready to meet it with the correct treatment. The first indication of its presence is the appearance in the center of the crown of the young leaves, just unfolding, slightly touched with a reddish yellow or purplish yellow tinge, unnaturally crinkled and smaller than normal. If not arrested the disease soon takes entire possession of the plant and all its leaves, old and young, are greatly shrunken, being scarcely larger than one's finger-nail, giving the plant a pinched appearance. The closest examination with the microscope fails to reveal anything in leaf, stem or root abnormal except the size and color of the leaves. The name "white bud" is sometimes applied to it on account of the bleached-out color of the youngest central leaves in the crown. There is evidently a lack of chlorophyll or coloring matter, just as there is a lack of blood in those cattle dying of starvation in the piney woods in winter, which the native farmer says perished of "white mouth." A symptom is substituted for a disease in both cases.

The remedy for the diseased (starving) plant is simply—feed it. Kainit seems to be about the quickest in its restorative effects, but care must be used in applying it not to sprinkle it directly on the foliage, or the salt in it will badly stunt the plants if it does not kill them outright. Sulphate of potash is safer. Probably the best application in general will be one of a good complete fertilizer. Let it be strewn in a light furrow; close to the roots, say two inches, so that it may begin to act on them speedily; and thinly sprinkled along, so as not to "burn" them, and then covered with the same implement. They ought also to be hoed at once, if merely to break the crust around them and admit the air to the roots. If the weather is very dry the fertilizer can not be dissolved and become available to the roots and may lie several days or weeks without taking effect; in this case it is necessary to dissolve it in water and pour a little on the affected plants. The whole secret of the treatment is, to furnish the plants something to eat as soon as possible.

Dieback generally makes its first appearance before hot weather is over in the fall; rust is more likely to strike the plants after the nights have become considerably colder. In both cases prevention is better than cure. Feed the plants moderately and steadily, to keep up an unbroken growth. If the plants are set in July or early in August, it is better to fertilize too little, or none at all, for a month or six weeks, even if the plants get somewhat "off color " (yellowish), rather than to fertilize too much at the outset and not be able to maintain the pace up to the beginnning of cool nights, when the liability to dieback measurably ceases.

PICKING.

In the North, where the picking season lasts only about two weeks in any given section and the berries come on very rapidly it is possible, with care, to pick them neatly enough in the field to bear shipping without sorting. In Florida this is not possible. The berries ripen so slowly in March and April when the sun is low in the horizon, lingering on the plants for weeks, that the insects have more opportunity to gnaw them, the rot is more likely to speck them on the underside, and, altogether, it would require a far more intelligent and careful set of people than negro women and children usually are to pick a cup of berries fit to be shipped without sorting. A packing house and packing tables are therefore indispensable.

It is usual to provide round pasteboard tickets to be given to the pickers in the field; these are printed for one quart and six quarts, since six quarts is the most convenient number to carry to the packing house in a tray. These may be cashed with money or with dollar tickets and redeemed at the end of the week.

With this rollicking and irresponsible race it is absolutely necessary to bear a firm hand. Let the foreman assign each picker his or her rows and see that they stick to them, no matter what happens, until they are picked clean. If not watched the scampish ones will abandon rows which do not seem to yield well and steal over to others which promise better pay. Forbid them from wrenching and twisting the plants roughly, from running crossways of the beds, from rolling or lolling on them, etc. It is well, if possible, to prohibit all conversation except with the foreman. In hot weather require them to set their quarts in the shade or cover them with a wisp of weeds until gathered up. Allow no one to hold several berries in the hand; but insist on their being placed in the cup one at a time. Let no one seize the berry, but take it by the stem, pinching this off with the thumb nail about an inch long. It is best to require each picker to bring his own berries to the packery in a tray, then there will be no confusion and miscount.

If shipping by express without ice it will pay the grower to get his pickers into the field, if possible, as soon as there is light enough to enable them to see the color of the berries. When they are bathed with dew they are cool and solid; they will rattle when poured down on the table. Spread them out thin in the shade on newspapers, to be replaced when dampened, and let the breeze draw over them until dry or very nearly. After the sun has shone on the plants for two or three hours in the morning the berries expand and become soft; the slightest pressure will rupture the skins and make a "mess" on the table. If picking has to continue through the heat of the day, these berries are not fit to ship by express; they require to be placed in the refrigerator as soon as crated.

SORTING AND PACKING.

Some packers have a sorting machine, a narrow endless band revolving on a roller at each end of the machine, turned by a crank. The berries are poured on this band and as they pass before the sorter they are stirred and culled, finally falling down a narrow chute into the cup or basket. When sorted by hand they are spread out thin on the paper and a finger with the point bearing on the paper is shoved around among them, thus turning them over without clawing and bruising them. It will pay to reject the very small berries as well as the gnawed or specked ones. Five quarts of berries with all the small one retained will frequently bring less money than four quarts or even three of sizable berries. One of the most conscientious and tidy men we ever knew, who rigidly rejected all specked or imperfect berries but put in all the small ones, wondered a long time over his low returns, and finally a friend in true kindness told him the reason.

"FACING."

"Facing" or "plating" is legitimate and expected in all markets, provided it is kept within bounds. It is not dishonest to put a handful of nice berries on top of the cup, loosely laid on; but it is a mistake to handle the berries so much as is required to place each one separately, even wedging them togther to make them present a smooth surface. When the weather is so cold that they can travel to the North without any perceptible shrinkage, this practice may be tolerated; but in the warm weather usually experienced here in March and April, any berry that has been jammed into its place will be so injured in appearance, if not ruined, that when the basket arrives it will have to be refaced or else it will appear greatly defaced.

Then, if all the nicest berries have already been used for this purpose and have to be either thrown away or put into the bottom of the cup, the berries can hardly be made presentable.

A shipper without reputation will have to plate his berries more or less, because it is expected and because "everybody does it." But an old shipper who has created a name for his berries, so that they are waited for and purchased in advance, can afford to neglect this piece of deception. Let him pour them lightly into the cup without handling them to brush off the bloom, hold it up and tap it several times to settle them thoroughly so that, when they arrive in market, they shall not have a shrunken, "skimpy" appearance. This is exceedingly important; it is better to settle them well and round up the center so that it will be flattened and bruised by the cup above than to have them arrive at their destination sunken a half inch or more below the top of the cup.

SHIPPING—COMMISSION HOUSES.

This paper is not a sermon; it is written for commercial uses alone. But shippers will do well to remember that worldly-wise old aphorism, "honesty is the best policy," and that city people, especially dealers, are the shrewdest people there are anywhere. The actual consumer who buys a few quarts for dinner does not, one time out of a hundred, know who shipped them. But the retail grocer, who is the arbiter of prices after all, so far as the grower is concered, soon learns the names of a large number of growers in Florida and remembers the main points as to the quality and condition of their respective shipments. These retail dealers can not be deceived more than once or twice by the same shipper.

We ask the growers to let an old and successful shipper give them a little personal advice. Select your commission house with the utmost care, then ship to that house through thick and thin. Do not get angry with your merchant because you do not hear from his house every twenty-four hours. The best and solidest houses generally take their time, remitting probably once a week. If your berries are good they will make a name; they will be spoken for in advance and will command the highest market price. But if you allow yourself to be wheedled away to this house or to that by every smooth and oily tongue that wags, shipping to a strange house you lose the benefits of your good reputation.

We have often thought that telegraphic reports from a market a thousand miles away are an injury rather than a benefit to the grower. The market for strawberries is very mercurial—up today, down tomorrow. A telegram may come, reporting great scarcity and high prices in a certain city, but before berries can get there the very opposite condition may prevail.

The writer has at times shipped for solid weeks to the same house, indifferent to the telegrams and to the nervous growers who continually consulted them and shipped to half a dozen places perhaps in as many days; and at the end of that time had a much better bank account than the men who were so anxious to catch the top of the market in several cities.

We do not say this to boast, but because we wish to strengthen the grower and encourage him in good business habits, as well as the proper cultivation of the plants.

PRESENT CONDITIONS.

A number of unfavorable conditions combined to render the season of 1897 one of the least profitable the growers of the State have ever experienced. In the central and southern parts of the peninsula the temporary collapse of the orange industry caused a number of the growers to resort to strawberry growing as a makeshift until their groves could grow up and become productive again. Thus there was an excessive number of shippers while the financial depression all over the country reduced the number of purchasers. Stations in the lower part of the State that had heretofore shipped crates, now shipped carloads. There was no central bureau of information and direction; the growers shipped blindly. Thus in one day, Lawtey, Gainesville, Hawthorne, Sydney and San Antonio all shipped by the carload to New York. There was no partition of the markets; gluts were of frequent occurrence, especially in New York, while at the same time other markets were without a sufficient supply.

In addition to this, the uppper sections of the strawberry belt suffered last spring from a visitation of the thrips. This insect occurs in sufficient numbers to be injurious only once in six, eight or ten years, and that generally after a warm, open winter like that of 1896-7. Its ravages upon the bloom can be measurably stopped it is said, by timely spraying with an infusion of whale-oil soap, but the trouble is the growers are generally so busy shipping that they take no note of the presence and effects of this parasite until they have reached such a pitch that spraying would afford relief too late. A new relay of berries would have to grow, as was the case last spring, and by the time they mature the shipping season is over so far as the northern markets are concerned.

These insects occur in the greatest numbers generally in the lowest, dampest situations. It is also a well ascertained fact that they attack perfect-bloomers, like the Newnan, while the pistillate or imperfect bloomers, like the Cloud, mostly escape—a phenomenon doubtless due to the fact that the favorite food of the thrips is pollen. Bradford county seems to have suffered a severer visitation than any other, probably on account of the low, wet soil of its flatwoods, which, otherwise, are so admirably adapted to strawberry culture. Yet, even in this unusually unfavorable year, there were growers who by energy, industry and good management made a profit, as usual, though smaller. Among these I may mention the following, from whom I obtained the information in person:

At Lawtey, Enoch Griffith, from six acres of plants, shipped 293 bushels of berries which netted him $4.40 a bushel. He is a methodical man, keeping strict account of all his expenses and receipts, and he stated that, after deducting all his expenses of growing and shipping, he had received about $60 a month for his own labor for the entire year. Besides his strawberry crop he raises a considerable part of his living, such as corn, sweet potatoes, rice, vegetables, pears, eggs and poultry, so that his store bills are very light.

W. S. Funk, from seven acres, shipped about 200 bushels, which netted him between $4.50 and $5.00 a bushel. His net prices were above the average, made so by his frequent shipments by open express, which is less expensive than the refrigerators.

C. H. Churchill shipped from four acres 180 bushels, for which he received over $1,200 gross. What his net receipts were he did not state, but they were probably not quite half the above amount, as his expenses were heavy.

Fortune Moulin, from four acres shipped 300 bushels and his net receipts were about $1,000. He is a careful, industrious grower and a shrewd shipper; he received much the larger part of his returns from shipments made to other cities than New York.

CONDITIONS IN SOUTH FLORIDA.

The cultural directions given in the foregoing pages do not always apply to the lower parts of the State. One instance is found in the advice as to the best time for setting plants. The growers in that section state that it is not advisable for them to plant in July, August or the first part of September, as is recommended for North Florida. At that time the heat of the atmosphere is so great and the ground so saturated with warm rain water that the plants "scald." If set after a shower in October, when the nights are cooler and longer, they will live, if well planted, and, as they practically grow all winter in that section of the State, they will come into bearing in the late winter or early spring, as soon as there is any considerable demand for berries in the northern markets, and will produce as abundantly as plants set in North Florida in July and August.

The growers living south of Alachua and Marion counties also generally depart from North Florida practice, in not mulching their plants. They claim that, owing to the warmth of their season, the mulch affords a harbor for crickets and other vermin which injure the fruit more than the mulching benefits it by keeping it free from sand. As I have had no experience in that section I have no opinion to offer, and can not do otherwise than accept the statements of the growers. Certain it is that they obtain strictly fancy prices for much of their early fruit, though this fact may be, and no doubt is, largely due to its extreme earliness.

In North Florida the growers have adhered pretty closely to a few old favorite varieties, while further down the peninsula there has been more experimenting with new varieties, which, however, do not appear likely to attain anything beyond a local reputation.

Central and South Florida has some advantages over North Florida in strawberry culture and some disadvantages. They have more recently embarked in the industry in the south and they are somewhat more inclined, on that account, to indulge in rose-colored statements. There have been newspaper reports of profits, in individual cases, exceeding anything substantiated of North Florida growers; but as I was unable to verify them by personal interviews I have not given them here. Certain it is that either section offers today and, in my opinion, always will offer to the shrewd, industrious and energetic strawberry grower, a reward not less certain than that of the cotton or corn grower in any State. It is not an industry which presents "bonanza" conditions or offers "bonanza" rewards. The man who cultivates intensively from three to six acres will seldom fail to add to his bank account each season; but if he goes beyond those modest limits he is almost certain to harvest reduced profits, if he does not suffer actual loss.

Paper by C. H. Ward,

OF ORANGE COUNTY.

The best time to set out plants is any time after September first when we have a favorable season for such work, for if the ground is dry and the weather hot it is much better to wait until it is cooler and the nights longer. If the ground is just moist, plants set out after four o'clock are pretty sure to live; care must be taken to see that the ground is well firmed around the roots and especially just below the bud (which should be just above the surface) as the new roots start from this point in a great measure.

VARIETIES.

Although the varieties and names of strawberries are legion, there are but few kinds that will do well in Florida.

I try new kinds every year, but they nearly always prove of so little value that they are discarded. I have, however, found two varieties which have done remarkably well with me. One is the Lady Thompson. This berry is staminate or perfect flowering and is very early, as well as a prolific bearer of very large, nice berries; I think for home use, or near by market, it is a great success, and for shipping early in the season when prices are high, it would do well.

The other berry I am very much pleased with is the Phenomenal. This berry was originated in Orlando from seed of the Hoffman, hence, its name—Phenomenal—for the phenomenal city of Florida.

THE PHENOMENAL STRAWBERRY.

This berry has many good points, among which may be mentioned its earliness—being one of the first to ripen. It is perfect blooming, very productive, a vigorous grower, free from rust, extra large size throughout the season, beautiful form and color, and is a good shipper.

We are all acquainted with the old reliable standby for Florida, the Newnan—but with me it has not done very well for the past two years.

Then we know the Michel or Michel Early, which seems to do pretty well for home use, but I am told it is not a good shipper; have not tried it myself.

SUMMER TREATMENT.

Our President says he would like to know how to carry our plants through the long, hot summer, or at least how to grow our own plants for fall setting.

I am sorry to say that up to the present time, I am unable to successfully answer this question. I have tried many different ways; by partially shading the plants, by clean culture and plenty of water in dry time, by planting corn, cow peas or some other crop among them, and by letting the grass and weeds grow, all with very poor results.

The best success I have had in raising plants, is to take the first new plants that make after plants are through bearing (which generally get well rooted early in June), and set them out on good, rich, moist ground and keep all runners off, and the ground well cultivated until the middle of August, when they will be in shape to put out abundance of first class plants for October planting; and these plants will give the best results. Plants that have grown all summer among a lot of grass and weeds are of little value, and are very hard to make live, and generally give bad results.

PROFITS.

Twelve or fifteen years ago there was considerable money made in shipping berries, but now one has to be very successful in all points in order to make much money. As the express charges range from ten to twelve cents a quart, there is not much money in it after prices get below twenty-five or thirty cents per quart in our Northern markets.

Orlando and Winter Park have usually been a good home market at ten to twenty cents.

The past season has been a fairly successful one with me, notwithstanding we had hard frosts in January at a time when we had just fairly commenced picking and prices were high. Our next crop came on a month later and came into competition with all the rest of the State, and in fact Charleston berries were soon after in the market. Then our home trade was a handy thing to help us out. So that at twelve to fifteen cents we did fairly well. For the past two weeks we have been picking our third general crop off same vines.

In what other State can they pick ripe berries six months in the year? Although I have not kept an accurate account of expenses and receipts this year, I think it is safe to say we will net about $250 per acre. In looking over my books I see the best we ever did on strawberries was in 1890. We planted out in August and September, 1889, three-quarters of an acre of the Florida Seedling or the Improved Newnan, and up to May 10th we had sold 3,488 quarts, for which we received $662.82, an average of about 18½ cents per quart. We also sold that year $100 worth of plants.

The best price we ever received for berries was for nine quarts we shipped to Philadelphia on January 3, 1890, which was a check for $19, or $2.16 per quart, net. The next shipment a few days later sold for fifty cents, showing that fancy prices will not last long at any season of the year.

While there may not be the chances for making five to ten hundred dollars per acre on strawberries, as there used to be, still I think with careful and intelligent management, one can make as much, or more, in this branch as in any other line of farm work.

Formula for Strawberry Fertilizer.

(See page 487.)

Nitrate of soda	200 pounds
Dried blood	300 pounds
Sulphate of potash (50 per cent. grade)	600 pounds
Dissolved bone	450 pounds
Acid phosphate	350 pounds

BULLETIN NO. 40. JULY, 1897

FLORIDA
Agricultural Experiment
STATION.

The Fall Army-Worm: Southern Grass Worm.

(*Laphygma frugiperda*, *Smith and Abbott.*)

— BY —

A. L. QUAINTANCE.

The Bulletins of this Station will be sent Free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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The Fall Army-Worm: Southern Grass Worm.

(*Laphygma frugiperda, Smith and Abbott*)

Reports from several localities in the State indicate that the fall army-worm has been unusually abundant and destructive during the late spring and early summer of the present year. As there is yet considerable time before cool weather will check their propagation and ravages, it has been thought best to publish this circular of information relative to their habits and treatment, in the hope that it may be of value in keeping this pest in check.

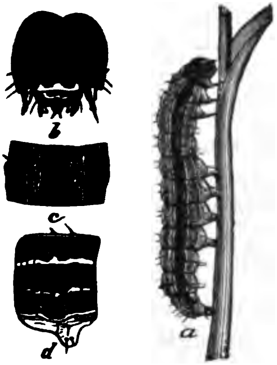

Fig. 1—a, larva; *b*, showing head, enlarged. (From Riley.)

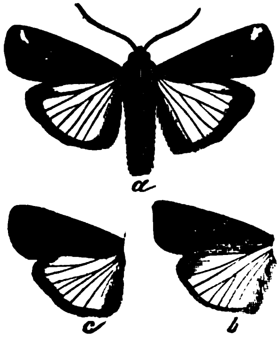

Fig. 2.—a moth, or adult. (From Riley.)

This insect also occurred last year in considerable numbers. During the latter part of August, and the first two weeks of September, they were reported as very destructive to crab-grass, and other grasses that were grown for hay. The present year they have been much more numerous, and an earlier brood than that of last year has been responsible for the damage. This fact indicates that the conditions governing their development have been more favorable this year than last, and if these favorable conditions continue, we may expect that the next brood, probably late in August or early in September, will be a very large one, and unless properly controlled may occasion considerable loss to the hay and other crops throughout the state.

The fall army-worm has been frequently confused with the true army-worm of the North, Leucania unipuncta. But it should be known that these are two distinct species, differing considerably in their habits and food plants. The fall army-worm is much more common South than North, and has been frequently reported from most of the Southern States. The true army-worm does not occur to any extent in Florida.

FOOD PLANTS, AND HOW IT FEEDS.

The insect has a wide range of food plants, as corn, oats, rye, cotton, garden vegetables, and in fact, almost any succulent plant may be attacked; it feeds more usually, however, on various grasses. In Florida it seems to be partial to crab-grass and crow-foot.

July 3rd, the crab-grass in the orchards on the Experiment Station was observed to be badly infested with this insect. In one orchard the larvae occurred in millions over an area of several acres, and the heavy growth of the grass was being rapidly consumed. The leaves and tender stems are eaten, and even the larger and older stems are frequently eaten quite low down. In the course of a week the grass had been eaten quite down to the ground over a considerable part of the orchard, and the larvae were working slowly out to the less defoliated areas. Several larvae may feed quite close together on a single stem, eating the leaves, the leaf-sheath or the stem. In feeding on the leaves, they feed mostly on the edge, eating in toward the mid-rib; the mid-rib is usually eaten down to near the stem, where a short ragged remnant of a leaf is left. The leaf-sheath is usually quite riddled with holes, or eaten off entirely. The stem is usually attacked after the leaves are about consumed, and is eaten from above downwards. The harder portion is frequently much chewed into.

In some cases, it may be supposed that these insects are of decided advantage, in keeping down the grass between rows of corn or cotton, but where it is desired to cut the grass for hay, their assistance becomes an injury; and it is well to remember that the larvae may attack the crops themselves, in case the grass is devoured before they have attained their growth, and are ready to pupate. The next brood also might give serious trouble.

DESCRIPTION OF THE INSECT.

Eggs—The eggs of the fall army-worm are deposited in small clusters, and often in layers, two or three layers placed one above the other. This whole egg mass is usually covered with the yellowish colored hairs from the abdomen of the female. An individual egg is almost spherical in shape, pale fulvous in color, and marked and ribbed much as illustrated in figure 3, a, showing the egg of Agrotis saucia enlarged. The eggs are usually placed on the under side of leaves of the food plant, but they have occasionally been found on leaves upon which the larvae are not known to feed.

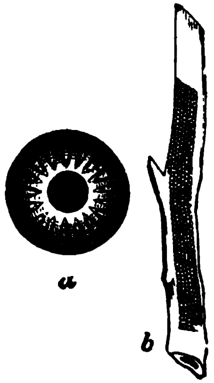

FIG. 3.—a, an egg of *Agrotis saucia*, enlarged; b, egg-cluster, natural size. (From Riley.)

Larva—The fall army-worm is illustrated in figure 1, a, about the natural size when full grown. In length the larva measures about one and one-half inches. In the color there is considerable variation, and also in the markings. The general ground color varies from pale brown to dirty green. The dorsum, or back, is brownish with a narrow line running down the middle. On each side, just above the spiracles, or breathing pores, is a rather broad, dark strip extending down the body; it is about one-third as wide as an individual segment is long. This dark band is bordered above by a narrow strip of yellow. Below, the larva is a dirty greenish white, unmarked. The head is pale yellowish brown, with a distinct white mark, shown in figure 1, b. Thoracic legs well developed; prolegs normal. The shield or dorsum of prothorax is somewhat darker than body, with the dorsal line and the yellow line bordering the dark subdorsal line, extending conspicuously through it. There are numerous black shiny tubercles distributed over the body; from each of these, arises a dark hair-like bristle. On the second and third segments these turbercles are arranged in a transverse row, and are quite large. On segment eleven the dorsal tubercles are arranged in the form of a square, while on the twelfth, they have the form of a trapezoid.

Pupa—The pupa is of a bright mahogany brown color, one-half inch in length. The caudal end terminates in two diverging horns, forming a fork.

Adult—The moth into which the fall army-worm develops is illustrated in figure 2, a. This figure indicates its natural size. The wing expanse is a little less than one and one-half inches; the body and head measure a little more than one-half inch. The fore-wings above, are more usually dark ash gray in color, variegated with fulvous, bluish white, and smoky brown. There is, however, much variation in the shade of the fore-wing, and in its markings. The hind-wings are pearly white, and transparent, margined with dusky, which is heaviest at the apical end. The entire under surface of the wings has a pearly lustre varying to fulvous. On the abdomen below, are four pairs of small black dots; the tip of the abdomen, below, ends in a bunch of rufous colored hair-like scales.

NATURAL HISTORY AND HABITS.

The injury is done by this insect in its larval or caterpiller stage. After hatching from the egg, the larva soon begins to feed; during its earlier stages, it feeds mainly upon the leaves, eating out the parenchyma in long narrow grooves, parallel to the margin of the leaf. As the larva grows rapidly, it soon begins to eat along the margin of the leaf, as previously mentioned. When ready to pupate, it works an inch or so below the surface of the soil, and there makes a small cavity or cell, cementing the sand together with a small amount of silk. From one to two days after this cell has been formed, the change to the pupa occurs. This condition lasts for about seven days, when the adult appears.

There seems to be considerable regularity as to the occurrence of broods, although larvae of various sizes may be observed at the same time. But these all seem to pupate within a short time of each other, and a field may be badly infested, and a week later be quite free from them. The time of the appearance of the adults of a brood during the summer, appears to be confined to a few days.

NATURAL ENEMIES.

Fortunately there are several natural enemies of this insect which serve greatly to keep it in check. In the field, a large reddish-brown wasp (Polistes bellicosus?) was frequently observed to destroy these larvae. After catching a worm, the wasp removed from the skin the food in the alimentary canal, gradually working it forward and out through a cut in the skin near the head. The remaining portion was then rolled up and chewed awhile with the mandibles. This was possibly swallowed, though the act was never observed.

There are several other species of wasps that attack these larvae. Much good work is also done by a species of Tachina fly, an insect much resembling the house fly, but larger. These flies were bred from larvae placed in breeding cases, in considerable numbers. The maggot of the fly devours the interior of the worm, causing its death. Another fly, a species of Bombylid, or bee fly, was also bred from these larvae in such numbers as to indicate their value as insect friends.

Various other insects probably aid in the destruction of the larvae of the fall army-worm, as ground-beetles, tiger-beetles, lady-birds, the spined soldier bug, wheel-bug, asilid flies and mantids. Toads are also of great value, and should always be encouraged around fields and gardens.

TREATMENT.

The value of the hay crop is sufficient to make it profitable to take steps to check the ravages of this insect; and aside from their damage to grass designed for hay, there is the danger of their further increase in succeeding broods to such an extent that various other more valuable crops might be attacked.

The old adage, "a stitch in time," is quite applicable in treating insects, and is particularly applicable to the species under consideration. The earlier broods of the larvae should be carefully watched for, and destroyed, thus greatly reducing the chances for their abundance in succeeding broods. These broods are usually more or less gregarious in the fields, and it is quite practicable to destroy them with Paris green. This should be thoroughly mixed with water in the proportion of one pound of Paris green to 125 to 150 gallons of water, and applied thoroughly to the infested grass with a spray pump. There is usually difficulty in getting the spray to stick to the leaves of grasses, and it has been recommended to put enough soap suds in the water to make it more adhesive. The use of cheap molasses would probably accomplish the same result. The spray may also be used against the larvae when they have attacked other plants. If plants are to be sprayed that are easily "burned" by Paris green, a pound of powered or quick-lime should be made into a thin paste, and this poured into the mixture of Paris green and water. One or two good rains after spraying, would be sufficient to wash the poison from the grass, and it could safely be cut for hay.

If the larvae are not observed until they are quite abundant, and the grass is being rapidly devoured, it would probably be best to plow them under as deep as is practicable. This would destroy the younger larvae, and if the older larvae pupated, they would be so deep in the soil that the moths would probably not be able to work their way to the surface. And it is not improbable that the majority of these insects would be males, as various experiments seem to indicate that when animals are under-fed, and surrounded by unfavorable conditions during their earlier stages, the male sex greatly predominates. A late crop of hay could in many cases be cut from fields thus plowed.

Where practicable, a large roller could be used to crush the larvae. This would be practicable in oat or rye fields.

The foliage of orchard trees is sometimes attacked, after the grass has been quite consumed. To prevent larvae from crawling up the trees, a roll of cotton should be tied rather loosely around the trunk, a short distance above the ground.

BULLETIN NO. 41. **AUGUST, 1897.**

FLORIDA
Agricultural Experiment
STATION.

A FUNGUS DISEASE
—OF—
THE SAN JOSE SCALE
(*Sphaerostilbe coccophila*, *Tul*)

BY
P. H. ROLFS.

The Bulletins of this Station will be sent Free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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1897.

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Summary.

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1 It has been definitely established that insects are subject to diseases.

2. Diseases of insects have been, and are being employed to destroy insect pests.

3. Some diseases of insect pests may be disseminated artificially with a profit.

4. This disease of the San Jose Scale is present on at least three continents and in many countries. In several instances it is recorded as an important factor in controlling scale insects.

5. It is doubtless native to Florida as it occurs on a native scale (Aspidotus obscurus) in our hammocks.

6. This fungus may be transferred to trees affected with San Jose Scale and a disease produced among the scales.

7. Large quantities of material may be produced in the laboratory in a short time and at slight expense.

8. The laboratory-grown material may be applied successfully by fruit growers.

9. This fungus cleared the orchards more effectively of San Jose Scale than could have been done by many sprayings.

10. It is now being tested in the North and West.

A Disease of the San Jose Scale.

Introducton.

A close study into the members of the insect world has revealed the fact that they often suffer with maladies that sweep away their members by myriads. The expression that the climate is not suited to a certain species of insect is quite common and usually accepted as final, but it only states our ignorance of the true state of affairs; it is simply an admission that we do not know the specific factor that workes against the increase of a certain species. Closer study on this subject has revealed the fact that insects are the prey of many and varied organisms.

The first important advance in the study of insect diseases was made by Dr. Louis Pasteur, an agricultural scientist of Paris. The silk industry of Europe in 1870 amounted to more than a hundred million dollars. The greater portion of this was produced in France, but in a few years the output in that country was reduced to half the normal proportions by a disease of the silk worm known to the French as flacherie. The working of this disease was very misterious and could not be explained easily. Pasteur began the study on this malady under many difficulties but finally succeeded in proving that it was due to a bacterium. After learning what the real cause of the disease was it became quite easy to suggest measures for its prevention. Pasteur proved that the disease could be transmitted from sick silk worms to well ones and that when well ones were brought into the breeding cases where sick ones had been kept, they would become diseasd. The discovery was so different from anything then known by the agricultural people of France that it required frequent public demonstrations of the fact before it was generally accepted. This was accomplished in such a masterly manner that Dr. Pasteur received special recognition from the French government.

DISEASES OF THE CABBAGE WORM.

In December, 1883, Prof. Forbes, of Illinois State University, delivered an address to the Illinois State Horticultural Society in which he gave an account of work in his laboratory with a disease of the cabbabe worm (Piers rapae), Prof. Forbes' object being just the opposite of Dr. Pasteur's. Prof. Forbes had proven very clearly that a disease occured among cabbage worms and that this could be disseminated artificially among these insects (Trans. Ill. Hort. Soc. Vol. 17, P. 29.) After it was settled that this was a contagious disease, it was sent to the neighboring State of Iowa. Prof. Osborn, Entomologist of the Iowa Agricultural College, infected a cabbage field with it and has found that it reappears in successive years and that it has been an important factor in keeping down this insect.

CHINCH BUG DISEASE.

The chinch bugs are often exceedingly destructive in the grain fields of the North-West and West. Often entire grain crops are destroyed and even the corn crops severely injured. A disease has been discovered among these and several entomologists have interested themselves disseminating it and collecting evidence from the persons to whom the material has been sent. Chancellor Snow, of the Kansas University, has been especially active in this line and has met with the most flattering success. Prof. Forbes, of Illinois State University, has also worked on this chinch bug disease, and has had good success. Prof. Osborn, of Iowa Agricultural College, has also given this matter careful attention, as has also Prof. Lugger, of Minnesota State University. Prof. Webster, of Ohio State University, has disseminated the chinch bug disease in grain fields of Ohio, but it has not been so successful in that State.

POINTS TO BE CONSIDERED.

Several points must be taken into consideration before attempting to introduce such disease among insects. First, we must have some germ that finds the particular insect vulnerable to its attack. The germ that causes the disease among cabbage worms, before mentioned, does not attack chinch bugs nor does the chinch bug disease attack the cabbage worms. It is plain, therefore, that we must have a particular germ to cause disease of particular insect. Second, the insect must have such habits as will expose them to the attack of that germ. As long as the chinch bugs are not abundant enough to congregate, the disease makes slow progress. This same disease attacks other insect but fails to destroy many of them because these insects do not congregate in large numbers. The disease of the cabbage worm could not spread rapidly among chinch bugs because the disease enters the body of its hosts (the cabbage worm) with its food. The bacteria lodging on the surfaceof the food plant are eaten by the cabbage worm and then set up a disturbance in the digestive system of the insect. Chinch bugs obtain their food by sucking the juice from the interior of the plant which normally contains no bacteria. Third, the atmospheric conditions must be favorable. A warm, moist atmosphere is excellent for the propagation of the chinch bug disease while a dry and a cold atmosphere does not allow it to germinate and grow rapidly. We see, therefore, that the combatting of insects, by means of their diseases, is circumscribed by strict laws, each one of which must be fulfilled or all our efforts are without effective results.

One would conclude, on first thought, that the fulfilling of all these conditions is a very exceptional occurrence, but that these conditions occur frequently is evident from the fact that although insects increase with marvelous rapidity, they rarely cause great devastation. We are all familiar with the great locust incursion into States of the Missouri valley, but this insect was not able to hold its acquired territory for more than two years. The heavy rains killed eggs, nymps and adults. Diseases of various kinds came in to destroy myriads. The journey of the Colorado potato beetle east of the Mississippi is also fresh in our minds. Although there seems to be no general or wholesale destructive disease of this beetle, its enemies have so reduced its number that it rarely becomes distructive. This is Nature's own way of equalizing and distributing to each species its own allotted share.

IMPORTED INSECTS.

Insects introduced from other countries are often very distructive and spread with great rapidity. As we have seen in the case of the Horn Fly, which was introduced from France in about 1886, and became very distructive along the Atlantic coast of the United States, reaching Florida in 1891 (cf. Bulletin 17, P. 14, Fla. Experiment Station). The white fly, or mealy wing (Aleyrodes citri), the fluted scale (Icerya purchasi), and San Jose' scale (Aspidiotus permciosus), are all examples with which we are familiar. Many of us are familiar with one or more of them at a considerable expense. All of these insects will doubtless run their course in time and become only one of the myriads of species that prey upon the products of the soil. Just how much distructive work these pests will do before they are successfully counteracted by "natural causes" is impossible to say. In some cases they would doubtless destroy entire industries and thus limit their increase by cutting off their own food. Happily we can bridge the period by artificial means such as fumigation, spraying, etc. In this way we help nature to strike a balance. Prof. Webber has shown that nature is already setting up a reaction against the increase of the mealy wing (Aleyrodes citri). At the ninth meeting of the Florida State Horticultural Society, in Jacksonville, he exhibited a parasitic disease of this insect that he had found at Braidentown, (cf. P. 73, Proc. Fla. State Hort. Soc. 1896.) This fungus was exceedingly active in reducing the numbers of the mealy wing. It was a most fortunate discovery for the orange grower as the dissemination of this disease in the groves affected with sooty mould will prove a great economic factor in producing bright oranges. (See also Bulletin No. 13, Div. V. P. & V. P., U. S. Dept. Agri., by H. J. Webber).

SEARCH FOR THE NATURAL CAUSE.

During June, 1895, on a visit to the orchards affected with San Jose' Scale, at DeFuniak, there were strong indications in some places that the scale was less severe than it had been. A diligent search in several orchards did not reveal any "natural cause" for the diminution of the scale. A return to several orchards in May, 1896, proved that the former suspicion was well founded, so a strenous effort was made to find this "natural cause" that was operating on the scales. Some fruit growers suggested that it was the freeze of '94 and '95, but that could not be since the scale flourishes in States where the temperature goes below zero. Others suggested that it was the mild weather; that could not be the cause since the scale is quite at home a hundred miles farther south. Others suggested the recent drouth, but dry weather is favorable to the multiplication of this scale. As we had not had a rainy season that year this was not suggested. Inquiries were made of Mr. Geo. Mellish of orchards that were isolated and that were badly infested two years before and had not been sprayed, nor treated in any other way with a view of killing the scale. After two days' patient searching an orchard was found on the farm of Mr. A. C. Bailey. This orchard consisted of peaches and plums and was on cleared hammock with hammock adjoining. After looking about in the orchard for a short time we discovered that the trees which were badly infested two years ago were now entirely free from scale except that here and there where there were dead limbs with an abundance of dried scales, showing beyond the slightest doubt that these trees had been infested with this scale. It was not difficult to find dead scales in such a state of preservation that they could be distinguished from the allied species (A juglans-regiea, Coms.) so common in this section. Mr. Bailey could point out many trees that had been severely affected. Our remembrance of the matter was that the whole orchard was infested and many trees were considered too badly affected to be worth spraying. On referring to notes taken two years before (cf. P. 94, Bulletin 29, Fla. Agri. 7x. Sta., also P. 19, Bulletin No. 3, N. S. Div. Ento. U. S. D. A. by L. O. Howard), they were found to place this orchard among those that were badly infested. The most remarkable thing about the whole matter was that we were not able to find a single live scale on the trees that we were examining. This was the more astonishing since all the artificial methods employed in Florida were not able to so completely destroy the scale without killing the tree. In Florida the most thorough and repeated application of insecticides have failed to eradicate the insect when once firmly established.

THE NATURAL CAUSE FOUND.

Mr. Bailey was asked finally, if all the trees were free from scales, whereupon, we were taken to four or five that were still affected, with the result that diseased scales in great abundance were found on each tree. In every case where San Jose' Scale was found in this orchard we also found this fungus attacking it. To the botanist it is known as Spaerostilbe coccophila, Tul. The ordinary observer would overlook it entirely as the largest specimens are not over one-eighth inch high, though after it had been pointed out to the orchardists they had no trouble in discovering it in other trees.

Dr. L. O. Howard on page 54, Bulletin 3, N. S. Div. Entomology, U. S. D. A. (1896) makes the following quotation from Bulletin 26, by D. W. Coquillett, of the Division of Entomology, U. S. D. A. (1892), "A few weeks ago Mr. C. H. Richardson, of Pasadena, one of the county inspectors of fruit pests, showed me several pear trees in that locality which a year ago were very thickly infested with these scales, as was evidenced by the gnarled appearance of the branches as well as by the dry scales still adhering to the trees. After a careful examination of these scales scarcely a live one could be found. Mr. Richardson assured me that the trees had not been treated with any kind of insecticide and they certainly gave no signs of such treatment. The dead scales gave no signs of having been destroyed by lady birds, nor yet by internal parasites. Wishing to ascertain if this singular mortality was general in other localities, I examined several infested pear trees in this city, but found that the fruit and new growth upon them were thickly infested with scales, which were alive and to all appearance in a very thriving condition. It would appear therefore, that the mortality among the San Jose' Scales was entirely due to some low form of fungus growth." In a later paragraph Dr. Howard states, "We have therefore, recently (1896) secured through the kindness of Mr. John Scott, Horticultural Commissioner of Los Angeles county, Cal., a considerable quantity of dead and dying scales supposedly affected with this disease. Mr. A. F. Woods has conducted a careful examination of the material, at the instance of Mr. Galloway, to whom we referred it, and while the conclusions so far reached are not sufficient upon which to base a definite recommendation, there seems to be a specific disease which develops both in the insect and its covering." There is nothing in the papers at hand to show that the California disease is not the same as this one.

DISTRIBUTION OF THE FUNGUS.

This is the first time that this fungus has been reported as causing a disease of the San Jose' Scale, though it enjoys a wide distribution. It has been collected on three continents at least and in each case it causes a disease among scale insects.

M. C. Cook in his Vegetable Wasps and Plant Worms, published in London in 1892, calls this fungus, Coccus tubercles, and gives the following excellent popular description: "This well known parasite on dead coccus is not uncommon in Europe, and has been found several times in Britain. They form little rosy knobs, with a short, whitish velvet stem-like base. Sometimes it is conical and sometimes it is club shaped and rather hard and horny when dry. The whole mass is composed of parallel hyaline delicate threads, densely compacted together, bearing at the apex very long curved conidia, spores, which are acute at each extremity, and with three or five septa or divisions (but sometimes with evidently more), from seventy [70-25,000 inch] to one hundred micromillimetres [100-25,000 inch] long and five [5-25,000 inch] thick. It is supposed to be the conidia stage of some more perfect fungus, but at present this is merely a supposition (plate 2, Fig. 22). The bright red spots on dead cocci are recognizable by the naked eye."

Mr. Henry Tryon, entomologist to Queensland, Dept. Agrl. Oct., 1894, Bulletin No. 4, page 15 says: The Red Scale, the Circular Black Scale, and the Long Mussel Scale, were again frequently killed by another parasite, Microcera coccophila, [Sphaenostilbe coccophila, Tul.] reproductive organs of which could commonly be observed as small compact scarlet masses emerging and ascending from their edges.

Prof. T. D. A. Cockerell records this fungus from Jamaica as occurring on Aspidiotus articulatus, a scale infesting citrus trees. (cf. Bull. Bot. Dep., Jamaica, Oct. 1892.)

Messrs. Ellis and Everhart, in North American Pyrenomycetes, page 111, say that this fungus has been collected in South Carolina by Ravenel and in Florida by Dr. Martin.

It is a common disease of Aspidiotus obscurus Coms.. It was first discovered on this insect by Mr. A. L. Quaintance in November, 1896. Subsequently it has been found in great abundance in a number of locations. It was also found by myself in February, 1896 on oaks planted in the streets of DeFuniak, Fla. From the foregoing facts it is quite reasonable to suppose that it is quite generally distributed throughout Florida and the South, and not imposible that it has found its way to California, but definite information on that point is not at hand. It seems quite certain that it is a native to Florida, and from its wide distribution among the native scale, A. obscurus, Coms. This fact makes it the more interesting and valuable as a remedy against the San Jose' Scale.

ARTIFICIAL DISSEMINATION.

BY MEANS OF DISEASED SCALES. — The next most important point, after finding a disease of great distructiveness, is to discover how it may be disseminated by artificial means. A test of this was made immediately after the fungus had been discovered. Some branches containing diseased insects were cut from Mr. Bailey's plum trees and were taken by Mr. Geo. Mellish and tied into trees affected with San Jose' Scale. The orchard belonging to Mr. Mellish was entirely free from disease of San Jose' Scale and several miles from Mr. Bailey's orchard. Six weeks later the orchard belonging to Mr. Mellish was visited and it was found that the disease of the insects had spread to a considerable distance in the tree to which it had been transferred. The orange colored prominences could be detected on many scales within eighteen or twenty inches of the infested stick that had been brought from Mr. Bailey's orchard and stick had not yet lost its virtue.

This test decided the matter beyond reasonable doubt that the disease could be disseminated by carrying sick scales from one orchard to another and also that it may be carried for long distance and used with good effect.

The operation is very simple. It may be stated briefly as follows: Select a branch of any tree holding San Jose' Scales affected with the disease; cut off a piece, eight, ten or twelve inches long; tie this piece firmly to the upper side of a limb infested with San Jose Scale, so that the two will lie parellel; and in contact for as great a portion of their length as possible. This is a certain and practical method of starting the scale disease in an orchard.

By Means of Spores Grown in the Laboratory.—It is a well established fact that it is possible to grow various moulds, bacteria and other organisms in the laboratory, upon material free from all other organisms than the particular one that is being studied. Organisms grown in such pure cultures may be studied to best advantage; in fact a botanist cannot do work in the study of animal and plant diseases of scientific merit and worthy of popular confidence unless he studies with pure cultures. It is necessary to have special apparatus, a laboratory, and to follow certain definite rules to produce a pure culture. This is no greater feat to the mycologist, however, than it is for the horticulturist to grow a pure variety of tomatoes. It is not necessary to go into detailed discussion of this matter, but we should keep it in mind clearly, that a pure culture of this fungus contains but one organism, and that the specific cause of the death of this scale.

THE MEDIA.

Immediately upon arriving at the laboratory steps were taken to obtain pure cultures of this fungus. The first step was to prepare sterile culture media. As it was a matter of experimentation to learn upon which this fungus would thrive best, a considerable number of different medias were prepared. Acid, alkaline and neutral agars; acid, alkaline and neutral gelatins; sterile potato; acid, alkaline and neutral bread were experimented with.

The acid agar proved to be the best of that group and the alkaline the poorest. The acid gelatine was better than any of the agars and the best of the gelatine group, while the alkaline gelatine was the poorest of that group. Sterile potatoes produced a good growth and a moderate quantity of spores. Of all the media tried, slightly acid bread proved the most successful and produced spores in greatest abundance. The fungus grew readily on slightly alkaline bread and better on neutral bread but the finest growth and greatest abundance of spores were produced as stated before, on slightly acid bread. Bread being porus, the fungus permeates the whole piece and produces myriads of spores in the pores, thus adding greatly to the spore producing surface of the medium. The spores germinate readily in distilled water, but of course, cannot do more than this. After germination the spores and mycelium remain vital for a few days and then become sterile.

As soon as practicable a quantity of spores were grown in the laboratory to be used in the field for artificial infection. Six four-inch petrie dishes of acid bread were inoculated from pure cultures and in three weeks these were taken to the field and the spores applied to various trees infested with San Jose' and other scales. A piece of bread about an inch square from a petrie dish was placed into a quart of water and shaken until the bread was broken up and the spores evenly distributed in the water. This was then applied to the scaley tree by means of a sponge or cloth or sprayed on.

EXPERIMENTS.

Experiments one to five were located in an orchard belonging to Mr. John Astleford. This orchard is a considerable distance from others and the San Jose' Scale were not severe except on individual trees. The insects were spreading rapidly showing that they were having a healthy growth.

Experiment No. 1.—A plum tree sprayed twice with spores of this fungus prepared by placing some of the infected bread in a quart of water. The first application was in the afternoon and the second just before dark, July 29, 1896. A portion of the tree was then wrapped with a moist gunny sack.

Result.—February 20, 1897. Scales thoroughly inoculated. The disease having spread to many branches.

Remark.—The idea of wrapping moistened burlap or other cloth loosely about the treated limbs is well worth following out. It is a question of only a few hours whether the spores are to produce the disease or whether they will die. If a moist atmosphere prevails all is well and good, if drouth, the spores will die. The reason for this is brought out strongly in the study of the biology of this fungus, so it will not be stated here.

Experiment No. 2.—A peach tree in good condition, except severely infested with San Jose' Scale, which seemed perfectly healthy, was sprinkled late in the afternoon of July 29, 1896 with material similar to that used in experiment No. 1.

Result.—February 20, 1897. Insects not affected. No trace of disease.

Experiment No. 3.—A peach tree like the one in experiment No. 2, sprinkled July 29, 1896, with material similar to that used in Experiment No. 1.

Result.—February 27, 1897. Insects all dead.

Experiment No. 4.—A peach tree like the one in Experiment No. 2, sprinkled, July 29, 1896, with material similar to that used in Experiment No. 1.

Result.—February 27, 1897. Insects not affected. No trace of disease.

Experiment No. 5.—A peach tree a considerable distance from No. 2, but conditions very similar to the one in Experiment No. 2, sprinkled later in the evening, July 29, 1896, with material similar to that used in Experiment No. 1.

Result.—February 20, 1897. A large proportion of the insects dead and peeling off. The disease well disseminated throughout the tree.

Experiment No. 6.—A peach tree in an orchard near DeFuniak Springs belonging to Mr. G. E. Mellish, severely infested with San Jose' Scale was sprinkled, July 28, 1896, with material prepared as that used in Experiment No. 1. This tree showed signs of having been infested for a long time.

Result.—February 20, 1897. Scales all dead.

Experiment No. 7.—A tree under conditions similar to the one in Experiment No. 6. Sprinkled with material prepared as in Experiment No. 1.

Result.—February 20, 1897. Tree dead.

Remark.—The death of the tree cannot be attributed to the fungus. Microscopic examinations show that the fungus does not pierce the bark.

Experiment No. 8.—A quantity of the material was left with Mr. Geo. Hollowell, DeFuniak, Fla., who applied it to scaly trees much as described in the foregoing experiments, during latter part of July, 1896.

Result.—February 20, 1897. No infection could be discovered.

GENERAL REMARKS.

1. The conditions for the application of this material were adverse at the time inasmuch as a dry spell followed the applications.

2. The best time to apply the material is after sundown on a moist evening; this contition may be produced artificially see remark, Experiment 1.

2. The spores raised on bread germinate in a few hours and must find a suitable medium in which they may grow (E. g.; San Jose' Scale) or they will perish.

4. The spores produced in the orange colored protuberance (See plate I, figure 1) seen on scales live for several months in dry weather.

5. That so many of th experiments turned out favorably substantiate our former expectations that the material might be grown artificially.

6. The material can be produced in great quantities and its application to the insects is as easily accomplished as a single spraying with insecticide.

7. It is more thorough than insecticides.

8. While it is "Nature's own remedy" for striking a bal-

ance in Florida, it will doubtless be less effective in dryer climates.

9. It will be noticed that the cooperation of orchardists has been secured in making the initial tests, proving that the laboratory grown material is effective in their hands and that the orchardist who may not be a scientist can apply it properly.

10. Further experiments will perfect the methods of applying it.

11. The fact that this fungus is widely disseminated on a native scale insures a constant source of new material, thus avoiding the necessity of using any that may have become attenuated.

12. The fungus multiplies many fold more rapidly than the San Jose' Scale.

13. As soon as the insects have been killed rains wash the fungus and dead scales from the trees leaving no signs of the tree having been diseased except where the scales may have injured the tree.

BIOLOGY.

A San Jose' Scale attacked by this fungus is usually transformed into a mass of mycelia before there is any exterior appearance of a change. When the body of the insect has been consumed a bright orange colored protuberance forms at the base of the scale or at times it breaks through the protecting cover of the insect. This orange colored protuberance is the most conspicuous part of the fungus and the only portion visible to the unaided eye; these vary in size from an eighth to a fortieth of an inch.

Those that measure about a sixteenth of an inch are the most abundant under favorable conditions. Figure 3, plate II represents a cross section of a scale insect and the spore bearing protuberance magnified twenty-five diameters. The outlines of this figure were drawn by the use of a camera lucida. These spore bearing bodies may be seen in figure 1 plate I, as small projections enlarged less than two diameters. These small projections contain a great many spores, represented by figure 6, plate II (enlarged 120 diameters). These spores, under favorable circumstances, mature within six weeks from the time of infection. Countless numbers are liberated from the orange colored protuberances during rains, and are washed down the trees and some to the ground.

If a moist atmosphere continues for several hours these spores will germinate and produce sporidia, represented by figure 7, a, which at maturity, may be carried about in the atmosphere. In case the spores represented by figure 6 find lodgment in a place suitable for further growth a sporidium, represented by figure 10, is produced. Under favorable conditions, sporidia germinate in the course of three or four hours, otherwise they retain their vitality for only a few days.

These sporidia, represented by figure 7 a, on germinating in a situation where there is only a slight amount of nutriment for this fungus, produce a growth represented by figure 14. Figure 14 a represents the original sporidium which germinated and produced the larger mycelium, after which the branches b, c, d, e and f were successively produced. Consecutively with e and f, g and h were produced; then followed i and k. While g, h, i and k are morphologically aborted branches of the mycelium, they finally become enclosed in a wall and later are detached to perform functions similar to those of a sporidium. The production of the spore-like bodies, g, h, i and k marks a cessation of vegetative activity. These spore-like bodies, g, h, i and k have the power to germinate even in distilled water, but produce a mycelium that is not more than two or three times the length of the diameter of the spore-like bodies. If, however, the medium in which it is grown contains a sufficient amount of nutriment, vegetation goes on freely, and a fungus plant may result as in case of germination of a sporidium.

If a sporidium be placed in a slightly stronger nutrient solution, growth represented by figure 15 takes place. In figure 15 a represents the secondary spore, and b a spore-like body produced after considerable growth of the myceium had taken place. This spore-like body may be formed directly from the secondary spore or from the mycelium and may be liberated before other spore-like bodies are produced, or before the mycelium has ceased to grow. In other respects the body represented by figure 15 a is similar to figure 14 g.

If a sporidium is transferred to strong liquid nutrient medium germination takes place in a few hours and a much stronger mycelium is produced. Finally, by the production of spores and continued vegetation a dense felty mass is produced. Figure 16 represents a branch of the mycelium producing spores. Under these conditions spores are borne on sterigmata, a, b, c, d, e, f and g which were produced in succession as lettered. At h, is represented the beginning of a sterigma. These spores are produced one at a time and when fully formed may be detached by a slight jar, but if handled carefully they may remain attached loosely until as high as four have been formed when the formation of a fifth will detach one or more of the older ones. Some sterigmata produce more spores than others that seem to have equal advantages; some remain sterile (16 d). Spores produced in this way retain the power to germinate for nearly a month in a humid atmosphere, but lost it after remaining in a dry atmosphere for only a few hours.

In connection with these spores a very interesting phenommenon occurs. The mycelium seems to have a power of inhibiting the growth of spores produced in this way. In cell cultures great many spores collect near the mycelium, but do not germinate; when the same spores were removed only a fraction of an inch from the mycelium many of them germinated; and when they were removed to the other edge of the hanging drop, the normal proportion germinated.

The growth of such spores placed in distilled water is represented by figures 11, 12 and 13, in successive stages of development. Figure 13 represents the original spore, 11, enlarged into a rudimentary mycelium, which has divided into two cells and produced a spore-like body at lower end which is similar to figure 14 g.

At intervals on the mycelium such as represented by figure 16, hyphae are produced that protrude from the medium in which it is growing. The successive stages of these hyphae are represented by figures 17, 18, 19 and 20. The length of these to the spore bearing portion varies with the depth of the medium in which it is growing. It is apparent from the beginning that such a branch as represented by figure 17 has some special function to perform. Gravity seems to have no influence upon the direction, but it seems to take the direction of at least distance to atmosphere. By comparing it will be noticed that these hyphae bear sterigmata, similar to those in figure 16, which bear a number of sphaerical spores; the first one formed, or the one at the distal end, is the largest. These spores are easily dislodged, and are much slower to germinate than the spores represented by figure 16.

Figure 25 represents a very interesting form taken by the mycelium at times. In the beginning the mycelium does not seem to differ from the ordinary forms, but in the coures of four or five days this is changed into a necklace-like form represented by figure 25 a. A second portion of the mycelium, figure 25 b, has become much enlarged. This enlarged portion, 25 c, then produces spore-like bodies which germinate when they become detached, figure 25 d. After these spore-like bodies become detached more of a similar character may be formed.

Spores of this fungus were placed on agar gelatine, on live San Jose' Scale and on live obscure scale (A. obscurus) in culture cells. In these cases the spores developed in quite a different way from all but those represented by figuge 20. Figure 21 represents a young hypha. Figure 22 shows a hypha further developed. Figure 23 shows the sterigmata, also the beginning of sphaerical spores. Figure 24 represents a hypha at maturity. In a dry atmosphere these spores separate easily and may be carried about by the wind; in a moist atmosphere they cling together in chains. These spores have been kept for several days in a dry atmosphere without loosing their vitality. If twigs containing scale insects attacked by this fungus be placed in a moist chamber this kind of spores is produced in such quantity that they become visible to the unaided eye, making the insect appear as if covered with a minute blue mold. Pure cultures may be obtained with greatest ease by using these spores.

Such spores as are represented in figure 16 (with figures 11, 12 and 13) were sown in distilled water where they germinated in a few hours. At the end of twenty-four hours the mycelium had grown to eight or ten times the length of a spore. After about forty-eight hours further growth ceased. A very peculiar phenomena was noticed repeatedly: Spores under these conditions germinated in a short time and grew rapidly for about twelve hours, then grew more and more slowly until their full growth was reached in about forty-eight hours. During the early portion of growth the mycelia took independent courses, but later the end of 26 a bent towards 26 b, with which it united. In this case 26 b seemed to be benefitted by the union. This second mycelium then grew out to 26 c with which to unite, which in turn received support from 26 b. As this occured repeatedly it is difficult to resist the conclusion that there is some affinity between these different mycelia in distilled water. The mycelum of this fungus does not, as a rule, anastosmose in a nutrient media.

ADAPTABILITY OF THIS FUNGUS.

From the foregoing study into the biology of this fungus, we learn that it has an unusual ability to adapt itself to the various conditions which may surround it. The stage represented by figure 1, plate I, enables it to pass through long periods of drouth and long periods of cold. The stage represented by figure 16 occurs during the rainy season and is not confined, in its growth, to insects but may occur on other media. The spores represented by figures 20 and 24, occur during moist periods and greatly facilitate the multiplication and thorough dissemination. When periods of drouth or cold weather occur, the fungus is carried over such periods by means of the spores represented at figure 6. These spores usually lodge in such places as are not most favorable to the development of the fungus, so a sporidium, represented by 7 a, is produced, which may be carried about in the atmosphere. In case this lodges in an unfavorable place for the further growth of the fungus, a spore-like body that may be called a secondary sporidium, represented by figures 14 g, 14 h, 14 i, 14 k and 15 b, is produced, which in turn may be carried about in the atmosphere.

ACKNOWLEDGMENTS.

I am pleased to have this opportunity to express my appreciation of the special favors received from Dr. Wm. Trelease in

the use of the extensive library in the Missouri Botanical Garden and the library and well equipped laboratory of Washington University. The final work on the biology of the fungus and figures 3 to 23, 25 and 27 were done at the laboratory of the Washington University.

I must also thank Dr. Roland Thaxter for so kindly determining the specific name of this and other fungi for me.

Explanation of Plate I.

Figure 1. Spaerostilba coccophila, Tul. on Aspidiotus perniciosus, Coms. from an artificial inoculation on a peach tree. (Slightly enlarged.)

Figure 2. Cultures of Sphaerostilbe cocophila on bread. A portion of this culture was used to induce the infection photographed for figure 1. (Natural size.)

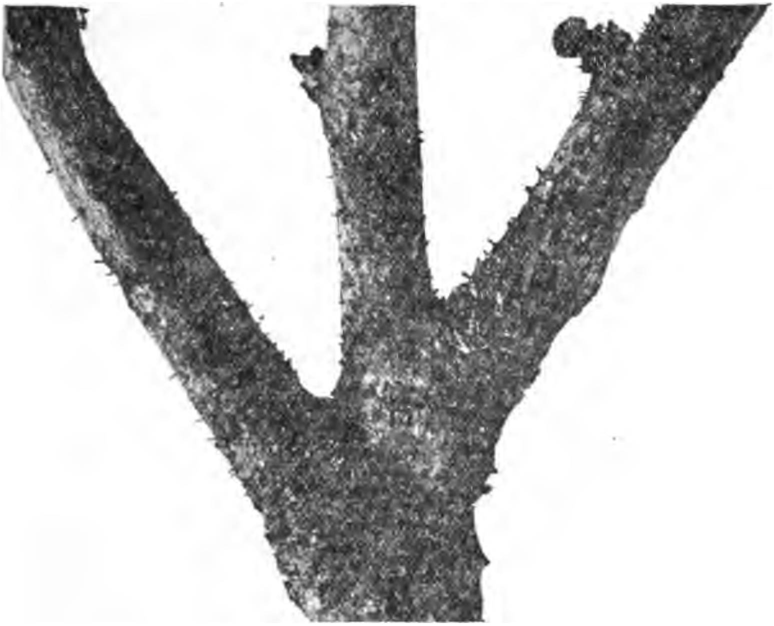

Figure 1.

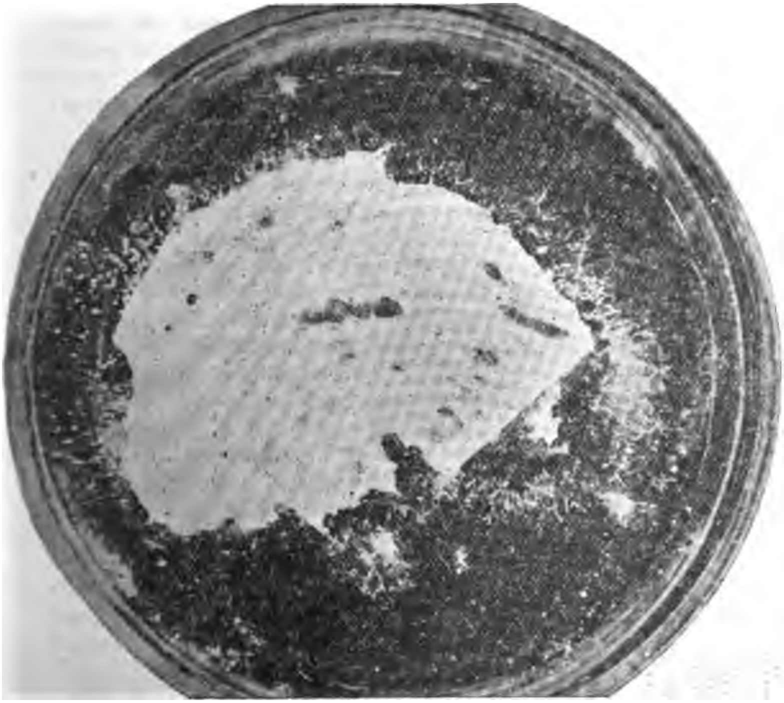

PLATE I.—*Figure 2.*

Explanation of Plate II.

Figure 3.* Cross section Sphaerostilbe stroma and San Jose' scale.

Figure 4.* Small conidium spore germinating.

Figure 5. Larger conidium spore germinating.

Figure 6. A large conidium spore.

Figure 7. A conidium spore germinating from a second cell.

a. Sporidium.

Figure 8. Large conidium spore germinating from both ends. The middle cell has not discharged its contents.

Figure 9. Further development of No. 8.

Figure 10. Sporidium completed.

Figure 11. Spore taken from figure 16 and placed in distilled water.

Figure 12. Development of 11.

Figure 13. Development of 11 completed and spore-like body produced.

Figure 14. Sporidium placed in a slightly nutrient media.

a. Sporidium.
b. First branch of the mycelium.
c. Second branch of the mycelium.
d. Third branch of the mycelium.
e. Mycelium from sporidium.
f. Mycelium from sporidium.
g, *h*, *i* and *k*. Spore-like bodies.

Figure 15.* Sporidium in medium containing more nutriment.

a. Sporidium.
b. Spore-like body.

Figure 16. Sporidium germinated in standard nutrient media.

a, *b*, *c*, *d*, *e*, *f* and *g*. Sterigmata.

Figure 17. Hypha grown in liquid media.

Figure 18. Hypha further advanced.

Figure 19. Hypha still further advanced.

Figure 20. Hypha with mature spores.

Figure 21. Hypha grown in solid media.

Figure 22. Hypha further advanced.

Figure 23. Hypha still further advanced.

Figure 24. Hypha bearing mature spores.

Figure 25. Growth in media.

a. Necklace form of mycelium.

b. Enlarged mycelium.

c. Spore-like body.

d. Spore-like body germinated.

Figure 26. Spores with anastosmosing mycelium.

a. *b* and *c*, original spores.

Figure 27.* Conidia spores attached to branching basidia.

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*Figure 3 enlarged 25 diameters.

Figure 4 to 14 and 16 to 26 inclusive enlarged 130 diameters.

Figures 15 and 27, 240 diameters.

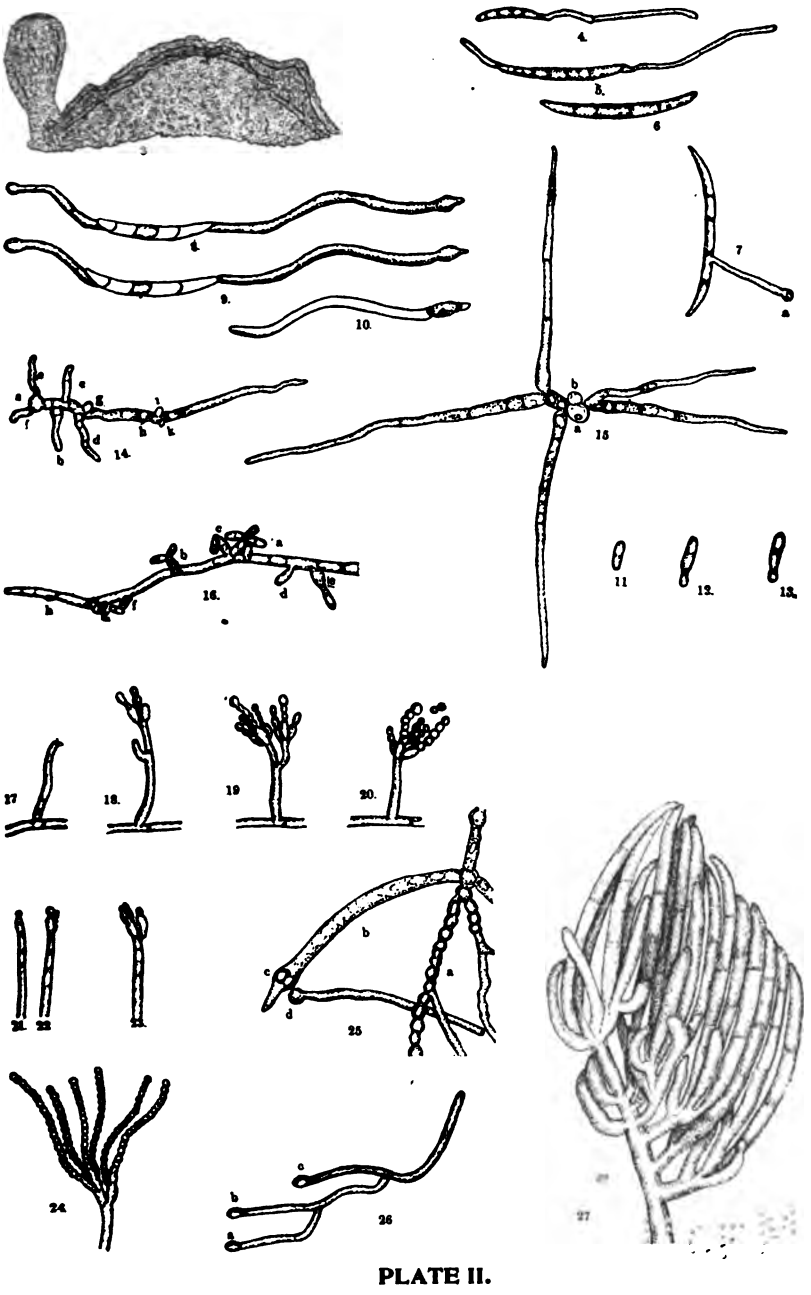

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PLATE II.

BULLETIN NO. 42. AUGUST, 1897.

FLORIDA
Agricultural Experiment
STATION.

SOME

Strawberry Insects.

—BY—

A. L. QUAINTANCE.

The Bulletins of this Station will be sent Free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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Some Strawberry Insects.

GENERAL REMARKS.

The cultivation of strawberries in Florida for Northern markets has become an industry of no inconsiderable importance. While the returns on the money invested in this industry have been in most cases good, it is believed that these returns might be materially increased by the recognition and proper treatment of the various insect pests that are known to attack this plant.

The fungous and insect enemies of a plant seem to increase in proportion to the extent of its cultivation. And there are certain years in which these enemies become more abundant and destructive than usual, and the loss of almost an entire crop may result.

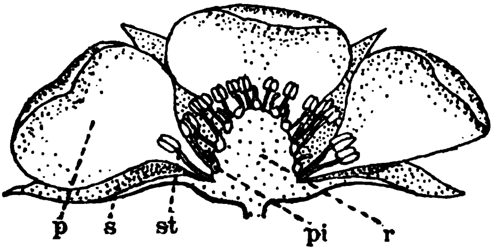

Fig. 1—Strawberry blossom in section: p, petal; s, sepal; st, stamen; pi, pistil; r, receptacle.

The strawberry plant is no exception to this statement, and it is essential that the grower should become acquainted with the various enemies of the plant, to the cultivation of which he is devoting his time and money. While the insect enemies of the strawberry plant in Florida are probably not as many as in many parts of the United States, yet they frequently occasion serious damage.

The present paper deals with the more injurious insects of the strawberry in Florida, with suggestions for treatment, which it is hoped will be of value to the growers of the State.

The accompanying figure (Fig. 1) illustrates, somewhat diagramatically, a strawberry blossom in section, showing the parts of the flower. By a study of this figure, the reader unfamiliar with the parts and structure of a strawberry blossom, will be better able to understand the remarks which follow.

THE STRAWBERRY THRIPS.

(Thrips tritici, Osborn—Fitch.) Order Thysanoptera. Family Thripidae.

During the past spring thrips have been unusually abundant in many parts of Florida, injuring the flowers of several different plants. Early in the spring, the blossoms of plums and pears were badly infested. Later, the blossoms of the strawberry plant were attacked, and the damage to this crop throughout the State has been quite heavy. The dry weather of the past spring was quite favorable to the development of thrips, and at the same time rendered infested plants less able to bear the effects of their ravages.

Thrips tritici, is an insect of rather wide distribution, and has a great variety of food plants. The insect was described in 1856 by Dr. Asa Fitch, in his Reports on the Noxious Insects of New York. He gave the insect the common name of wheat thrips, as it was at that time very destructive to wheat. This species has been frequently mentioned since Dr. Fitch's note, as causing considerable damage in various parts of the eastern U. S. and Canada. In the North, its injuries are confined principally to the various cereals, and to apple, plum and strawberry blossoms.

In Florida the insect may be found in various sweet-scented flowers, during almost the entire spring and summer. Usually they are not sufficiently abundant to occasion much damage. But conditions favorable for the development of thrips seem to have prevailed in the State during the past spring, and they have been with us in myriads.

The bloom of the strawberry plant seems to be a favorite food for this insect, and unfortunately, its effects upon these particular flowers are much more severe than on many others which it infests.

The food of thrips as an order is rather varied. Some species are recorded as carnivorous, others entirely vegetable eaters; but as a whole, the species probably feed upon vegetable substances. Many vegetable feeders live in the blossoms of plants; others live under bark, turf, and similar places.

Many flower-inhabiting species vary considerable in the parts of the flower which they attack, for there seems to be somewhat of a preference to some particular part, as the pistil, the stamens, or petals. The injury that these insects occasion is, therefore, dependent somewhat upon the particular part of the flower attacked, and the structure of the flower in question. If the petals are attacked in the roses, the resulting blackening, would be a serious drawback.

In the case of many other blossoms, if the petals were attacked, but little damage would result. As a rule no serious harm occurs from the stamens being attacked, as there is usually sufficient pollen produced to fertilize the pistils, and the fertilization is, if anything, assured by these active little creatures running over the pistil with pollen sticking to them. If the pistil is attacked, the result may be more serious, as is the case in the strawberry.

The same species of thrips may attack different flowers differently; as an example we may cite the insect under consideration. In orange blossoms, the petals and stamens seem to be most subject to attack. In the blossom of the strawberry, the pistil is evidently preferred. The resulting effect is widely different. In the case of the orange blossom no harm of consequence is done. In the strawberry, however, the attack on the pistil, if severe, will result in the destruction of the bloom.

The thrips were observed to be injuring strawberry blossoms March 10th, here at Lake City. They seem to have been present in injurious numbers somewhat earlier than this in other parts of the State, as the following editorial on "Strawberries and Pears" from the Florida Farmer and Fruit Grower, of March 27th, will indicate:

"To add to the trouble—though it may prove to have been a benefit in the end—the drouth, and thrips stepped in to curtail the output. A mysterious shadow crept over the bloom; the plants are unusually fine this spring, free from rust, large, vigorous, of high color and glossy; yet the millions of blossoms were observed to fade away like candles going out. Most growers thought it was a blight, caused by cold, dry winds, but this cause was totally inadequate to account for the effect, as these winds have prevailed but little, hardly at all, and the strawberry crop is hardy. A careful examination revealed that the blossoms were swarming with the thrips (Thrips tritici) a lively little worm, one twenty-fifth of an inch long, of a clear honey-yellow color with rudimentary wings. These eat the stamens, the petals, and apparently the pips of the little berry. Some are apparently sucked dry; though they remain green on the inside, they are almost as hard and dry as wood, do not expand any, become black on the outside and finally die. Others escape with a part of their pips eaten off, and they grow out disfigured, pips scattered here and there with spaces of naked core between them. The growers who have 'Clouds' state that they are less liable to the attack of thrips, than are the 'Newnans.'"

To definitely prove that the thrips were the cause of the blackening and wilting of infested blooms, several Newnan plants were brought to the laboratory, and all blooms but unopened buds were removed. A number of these buds were then inclosed in large glass tubes, plugged loosely on either end with cotton. As soon as these buds had opened, some were supplied with thrips, others were kept uninfested, as checks.

The thrips at once attacked the stigmas and distal portion of the styles, chafing and apparently puncturing them. In the course of ten or twelve hours many of the stigmas began to blacken, and twenty-four hours from this time, nearly all of the stigmas had blackened, and the styles were blackening half way down to the ovaries, and wilting perceptibly. In the course of another day, the styles had blackened to the ovaries and were plainly drying up. (See Fig. 2.) The ovaries also were attacked and blackened considerably from the chafing of the thrips.

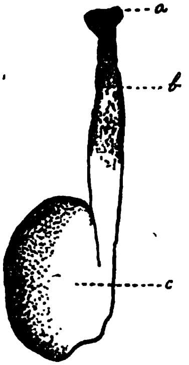

Fig. 2—Pistil dissected from strawberry flower showing the blackening and withering of stigma and style, due to thrips. a, stigma; b, style; c, ovary. Much enlarged.

By another day the entire young fruit, receptacle, and ovaries were black and dead, and the blackening in some cases had extended some ways down the fruit stalk.

It should be noted that other parts of the flower were attacked besides the pistil. The petals were sparingly attacked, particularly at their bases; also the stamens, principally the filaments. But as a whole, the preference was decidedly for the stigmas and styles, probably on account of the sweetish substance secreted by the stigmas, to aid in the germination of the pollen.

The blossoms in tubes not inoculated with thrips, did not show this blackening and drying up. In several instances where the stigmas were pollinated, fruit set normally.

The results seemed conclusive, yet the same experiment was made again in the laboratory, and also in the field. In the field, after all opened and infested flowers had been removed from a plant, it was covered with a lantern globe, by pressing bottom end into the soil, and fastening a strip of cheese cloth over the top. Ten plants were thus prepared. After several buds had opened into flowers, five plants were supplied with thrips, and five were kept as checks. This experiment confirmed the experiments made in the laboratory, and left no doubt that the thrips were responsible for the blackening and wilting of the fruit.

The injurious effect of these insects seems to be to a considerable extent in preventing the fertilization of the ovules. Since the stigmas are attacked, and decay soon sets in, the normal fertilization of the ovules is greatly retarded, if not entirely prevented. But there seems to be an unusually rapid blackening and drying up of the injured tissue. This occurs more rapidly than would be expected, if due to the non-fertilization of the ovules, and it seems that the immediate effect of the insects on the tissue itself should be taken into consideration. See figure 3, illustrating on the left, an infested flower cluster; on the right, a healthy normal cluster.

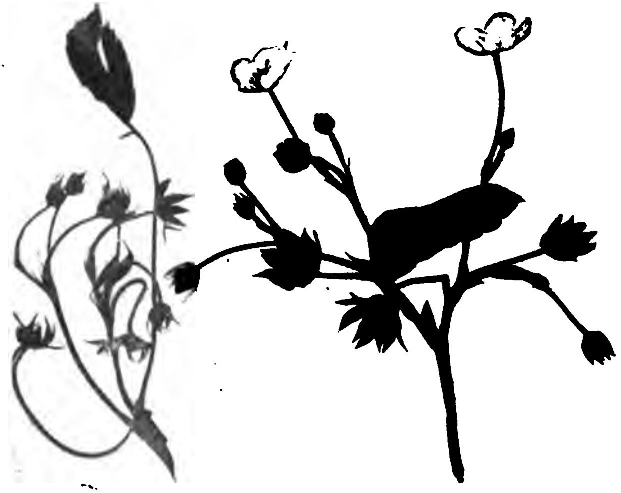

Fig. 3—Illustrating on the right, a healthy flower cluster; on the left, one that has been destroyed by thrips. From a photograph.

The exact manner of feeding on the blossoms was not accurately determined. The mouth parts of the Thysanoptera, represent an intermediate stage between biting and sucking mouth parts. The labrum, mandibles, maxillae and labium, although present are somewhat modified, particularly the mandibles and maxillae. These parts last mentioned are pointed, and plainly not adapted to chewing, nor are they well adapted to sucking. They seem to be used in a pricking or rasping way.

There is probably no poisonous effect produced by the punctures of these insects, as has been suggested at times of other insects.

LIFE HISTORY NOTES.

There are probably but few species of Thysanoptera whose life histories have been completely worked out, and probably no American species in which the life history has been carefully determined. Probably the most complete account of the life history of an American species is to be found in Bulletin No. 27, of the Iowa Agricultural College, p. 139, referring to the Western onion thrips (Thrips alii, Gillette).

Prof. Osborn here gives some observations, with those of Miss Alice M. Beach. The eggs of Thrips alii are said to be "deposited slightly beneath the surface of the leaf, and imbedded in the cell structure. The larvae hatch from the eggs, work their way through the surface of the leaf, issue, and very soon begin to feed upon the plant tissue. They evidently grow quite rapidly, and there is in all probability a number of generations each year, but just how many is not known."

With regard to Thrips tritici, not much can be said. Eggs are probably placed beneath the surface of the tissue, judging from the habits of its near relative, and from the fact that the female possesses a saw-like ovipositor. The egg state probably lasts about five days. The young when first hatched are exceedingly small, and quite colorless. They measure about .8 mm.; growth is rapid and by the end of the sixth day they are about one-half the size of an adult, and the body is distinctly yellowish. The pupae are less active than the adults or larvae. Adults of both sexes are very active, and fly readily. They have a curious habit in common with other species, of curling up the abdomen in a very threatening manner. When observed under a hand lense this appears very ludicrous. But this curling up of the abdomen seems to be necessary, for them to spread their heavily fringed wings, as Prof. Gillette has pointed out. I have never observed their doing this except to aid in spreading their wings preparatory to taking flight. As has been said before, dry weather seems to be favorable for the development of this species, but there are probably other causes also that have a marked influence on their abundance. During April and May thrips were quite abundant at Lake City. By June 3rd nearly all had disappeared from strawberry blooms and other flowers. At this date, August 1st, they are somewhat more abundant and are to be found sparingly in roses and other flowers. Probably these insects pass the winter both as adults and nymphs.

The length of time required for the destruction of a strawberry bloom will vary of course in proportion to the number of thrips infesting it. In some blooms as many as sixty-five insects were counted, but this is an unusually large number. Probably one-half that number would represent approximately the number more usually present.

DESCRIPTION.

"Male, length .75-.80 mm. (.029-.031 of an inch); width .20 mm. (.007 of an inch). Female, length, 1.10-1.20 mm. (.042-.046 of an inch); width, .25 mm. (.009 of an inch). Color, yellow, thorax tinted with orange; antennae with dusky annulations. Head from above nearly square, eyes occupying anterior angles. Antennae approximate at base, joint two, apical half of four, and six, dusky; joints three and five dusky at apex, the antennae appearing annulated under low power of microscope. Head, thorax and abdomen with a few stiff hairs. Legs concolorous with body, all the tibiae with two spines at the distal end, distal joints of tarsi a little dusky, proximal joints of tarsi with two spines. Wings narrow, hyaline, fringes whitish; anterior wings have a costal fringe of shorter ciliae than posterior ones, and the ciliae are intermixed with shorter, stiffer, spiny hairs, which at base replace the fringe; two rows of blackish spines on the upper surface of wing corresponding with subcostal and median veins.

Posterior wings with no discal spines, ciliae of anterior edge shorter and more spiny than those of posterior. Both wings have rows of very minute hairs on the surface. The males are shorter and smaller than the females, with wings reaching beyond the tip of the abdomen."—*H. Osborn. See figure 4 from a photomicrograph, greatly enlarged.

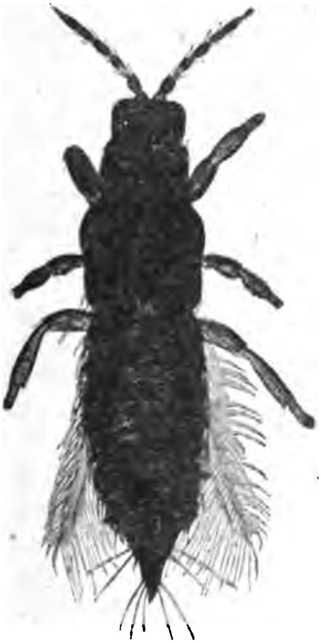

Fig. 4—*Thrips tritici*, from a photomicrograph, greatly enlarged.

Nymph, or Larva.—Length of body .75 mm. (.029 of an inch; width .20 mm. (.007 of an inch). Shape oblong, tapering caudad from about sixth abdominal segment, and cephalad from posterior corners of prothorax. Color yellow, antennae, lighter.

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*The Canadian Entomologist, p. 156, Aug. 1883.

Eyes reddish. Antennae short, joints shorter and broaded than in adults; fourth and succeeding joints not well separated. Body sparsely haired; under high power of microscope, body is seen to be covered with short, pointed processes. Head about one-half as wide as prothorax; rounded in front.

Eggs.—Bodies were frequently pressed from abdomens of females which are probably to be regarded as eggs. Size .6x.1mm. (.023x.003 of an inch); curved, oblong in shape. The number of these bodies observed in females varied from two to five. More usually three.

Dr. Fitch describes* what he regarded as eggs of this species, as very minute, oval, almost globular bodies, bright red in color, and attached to a leaf by a short, thick, crinkled stalk or stem, which is dull white in color. It seems probable that these bodies were not eggs of Thrips tritici as Dr. Fitch supposed.

TREATMENT.

Several different insecticides were tried against this insect, the results of which are herewith given:

Sulphur Spray.—Eight rows of badly infested plants were sprayed with sulphur spray. Three rows were left unsprayed as checks. Formula of sulphur spray used is as follows:

Flowers of Sulphur	3 pounds
Caustic Soda	2 pounds
Water	1-3 gallon

To this was added two gallons of water, the whole making a stock solution. The stock solution was used at the rate of one and one-half pints to twelve gallons of water, and applied to all parts of the plant with a barrel pump sprayer.

Immediately after spraying the bloom was carefully examined. A few thrips were observed to have been killed. Many seemed distressed, but the majority were not so severely injured but that by the time the insecticide had dried from the blooms, they were to all appearances about as lively as ever. The sprayed rows were examined again the next morning when the thrips were found as abundant as in the untreated check rows.

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*Noxious Insects of New York. Reports I and II, p. 307.

Flowers of Sulphur.—Four rows were thoroughly dusted with flowers of sulphur to determine its value as a repellant. Two rows were left as checks. No difference could be detected in the abundance of thrips in the treated and untreated rows.

Pyrethrum Powder.—Pure pyrethrum powder was dusted thoroughly on three rows, with a Leggett powder gun. Two rows were left as checks. The pyrethrum seemed to be of no appreciable value against the thrips. They were observed to feed readily amongst the powder adhering to the bloom.

Pyrethrum in Water.—Pyrethrum powder suspended in water was tried at the rate of one-fourth pound pyrethrum to six gallons of water. This proved to be of but little if any value.

Pyrethrum Decoction.—One-fourth pound of pyrethrum powder was steeped for an hour, the water breaking into a boil a few times. This was diluted with eleven gallons of water and applied with a knapsack pump. Two rows were sprayed, one kept as a check. Examination immediately after spraying showed that a small proportion had been killed, and others were more or less distressed. Many thrips had run out on the petals, and sepals, from which the solution soon dried and the thrips seemed to be unharmed. The next day no difference could be detected in the relative abundance of thrips in the treated and untreated rows. Doubled the strength of pyrethrum. Results some improvement on above.

Tobacco Dust.—Tobacco dust was thoroughly sprinkled over and worked among the leaves of one row of plants. One row was kept as check. No difference in the number of insects in the two rows could be detected, when examined at different intervals.

Tobacco Decoction.—One pound of tobacco stems and leaves was boiled for one-half hour in two gallons of water. This was strained, and diluted with four gallons of water and applied to four rows with knapsack sprayer. Two rows were kept as check. Immediately after spraying, examination showed this insecticide was particularly disagreeable to the thrips. A small proportion were killed or evidently dying. Most of the adults had left the flowers entirely. Examination the next day showed that the sprayed plants were much freer from thrip than checks.

Rose Leaf Insecticide.—This is an insecticide manufactured by the Louisville Spirit Cured Tobacco Co., Louisville, Ky. It is claimed by the manufacturers that it is an extract of tobacco, of a uniform strength of nicotine. It should be noted that in a decoction made by boiling stems and leaves in water, the per cent. of nicotine is quite variable owing to the variation in quantity of this compound in different plants. This Rose Leaf was used at the rate of one pint to six gallons of water, and sprayed thoroughly on five rows with a knapsack sprayer. Two rows were reserved as checks. Examination immediately after spraying showed that the insecticide was much more effective than anything yet tried.

Quantities of thrips were dead evidently where the spray had first touched them. Others were dying or trying to work their way out of the insecticide, but were soon overcome. The per cent. of thrips destroyed by this insecticide would probably be near sixty-five or seventy. The action of the fluid seemed to be that of a strong irritant, and was sufficiently sticky to prevent the insect from escaping, after the spray had struck it.

Kerosene Emulsion.—This insecticide was made according to the following formula:

Soap (hard)	½ pound
Water	1 gallon
Kerosene	2 gallon

Two quarts of this stock solution were used to six gallons of water and applied with a knapsack sprayer to four rows of plants. The thrips were killed in considerable numbers. However, many that were thoroughly wet were observed to crawl out on the higher parts of the petals, and probably eventually recovered. Probably a stronger solution of the emulsion would be quite efficient, but the danger of tainting the fruit would exclude its use. And the application of the emulsion of the strength above indicated, would probably slightly taint the fruit.

Carbolic Acid in Water.—This was used at the rate of one ounce of acid, to six gallons of water. The acid used was comparatively pure, being derived from carbolic acid crystals. This mixture was applied with a knapsack sprayer to four rows of plants, two being kept as checks. The use of this insecticide resulted in killing a small proportion of thrips and drove many from the blooms. Examination the next day did not show any marked freedom of the sprayed plants from thrips, as compared with checks.

Whale Oil Soap.—This was used in the proportion of one-half pound of soap to six gallons of water. Applied thoroughly with barrel pump sprayer. Three rows were sprayed, one was kept as check. This insecticide seemed to be of some value. Some insects were killed, and the flowers were comparatively freed from thrips. Examination of sprayed rows the next day did not reveal much reduction of thrips as compared with their abundance in the checks.

From the results recorded above it will be observed that the "Rose Leaf Insecticide" gave much the most satisfactory results. Its superiority seems to be in its slight stickiness to hold sprayed insects from escaping, and in the rapidity with which it acts upon the insects.

It was early observed that the thrips passed readily from plant to plant, many leaving the flowers upon slight disturbance; and some that had been caught in the spray were able to crawl out from the blooms and eventually escape to other parts of the field. This activity of the insects in passing to different plants explains somewhat their abundance in sprayed blooms, frequently in less than twenty-four hours after having been sprayed, and comparatively freed from the insects.

To get the best results, it seems necessary that an entire patch should be sprayed, and within as short a period of time as practicable. To test the value of such a precedure, the entire patch, save one row as check, upon which the foregoing experiments were conducted, was sprayed thoroughly with the "Rose Leaf Insecticide." The results obtained from this spraying indicated that much could be done to keep the thrips in check by its use when applied to the entire patch. The thrips were reduced throughout the patch at least one-half in numbers.

A second spraying of the patch two or three days later would probably have done much to exterminate them. But if the thrips were quite reduced, and a patch left for some time without spraying, in all probability the insects would become quite numerous again, from the fact that they are very abundant in many other flowers, and that they pass readily from place to place. Magnolia blossoms were most badly infested, and it seemed that thrips were more abundant in strawberry blooms, after a strong wind from the direction of a neighboring hammock containing many of these trees.

It should be borne in mind that in the use of an insecticide on strawberry plants during the fruiting season, an insecticide must be used that will not injure the ripe or nearly ripe fruit for market or eating purposes. The difficulties in finding an insecticide that is effective against the insects, and harmless to the fruit, are considerable. These conditions, however, seem to be fairly met in the insecticide under consideration. Berries thoroughly sprayed, and then well washed, carried no taste of the insecticide, that the writer could detect.

Possibly a strong tobacco decoction mixed with sufficient cheap molasses to make it slightly sticky would give satisfactory results against thrips.

It has been stated that the Clouds, a pistillate variety, are less subject to attack than the pollen bearing bloom, as the Newnan. If this be true, it would probably be an advantage to plant only enough pollen producing plants to insure the fertilization of the pistillate bloom. Both the Newnans and the Clouds, were carefully observed during the last spring with reference to this point, and in the case under consideration, but little if any, difference was observed in the number of thrips in these two varieties.

THE STRAWBERRY PAMERA.

(Pamera vincta, Say.) Order Hemiptera. Family Lygaeidae.

This insect, first described by Thomas Say, has not, I believe, been previously recorded as of any economic importance.

Thomas Say gives the habitat of this insect as *Florida. I have been unable to find any other reference to this insect, than his original description.

For several years past this insect has been recognized as an enemy to strawberries. In 1892 Prof. P. H. Rolfs observed the insects in considerable abundance among strawberry plants, feeding on the young green berries. Since that date it has been under more or less of observation in the field and it has been observed that it feeds to a considerable extent upon the fruit, seeming to prefer the younger berries; it also feeds on the petioles of the leaves.

As will be seen later there are several insects, whose injuries are essentially the same, that may be concerned in the so-called "buttoning" of young fruit. All strawberry growers are doubtless familiar with these buttons, as small, hard and woody berries, which do not develop into large and perfect fruit, but remain small and worthless. Almost any strawberry plant will have some of these buttons on it. A study of this insect, both in the field and laboratory, make it seem quite certain that it is responsible, to a considerable extent, for this buttoning of the fruit in certain parts of Florida. The tarnished plant bug, described later, occasions this buttoning also, but the tarnished plant bug is not nearly so abundant in strawberry fields in Florida as the species under consideration.

Specimens of the strawberry Pamera kept in the laboratory on strawberry plants, were observed to feed mainly on the ovaries of the young fruit. Walking around over the berry, the beak was thrust first down into one ovary, and then another, frequently fifteen or eighteen ovaries being pierced during the course of half an hour. As is well known, the ovary is, physiologically, an essential part of the fruit of the strawberry, and if a considerable number of ovaries are destroyed, the development of the receptacle, the juicy part of the ripe strawberry, is checked. This insect seems to destroy the vitality of the ovaries which it attacks; in case the attack has been severe, i. e. many of the ovaries of the fruit having been pierced, the berry rarely de-

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*Entomology of North America, Thomas Say, p. 333, Vol. 1.

velops to anything of value. Further growth is greatly checked, and the receptacle eventually becomes more or less woody, producing a "button." Very young fruit seem to suffer more severely yet. In such fruit, the receptacle is also attacked, and it usually results in the blackening, and eventual drying up of the berry. This effect was observed repeatedly in the laboratory; blossoms are sometimes attacked, with the same results. One insect may so pierce a very young fruit or blossom that it will die. After a berry has become a third grown it is probably safe from destruction from this insect.

The extent of the injury of an individual insect was not satisfactorily determined. However, it would be a moderate estimate to charge it with two or three young berries a day. But at this rate, from the fact that both adults and young feed on the berries, and that they are usually quite abundant, the total damage done by this species during a season must be considerable.

DESCRIPTION OF THE DIFFERENT STAGES.

Egg.—Length .88 mm.; width .43 mm. (.034x.016 of an inch); elliptical in shape; no markings; on the apical end are five short processes, each process ending distally in a thick hook, the hook projecting outward. See figure 5 from a photomicrograph, much enlarged.

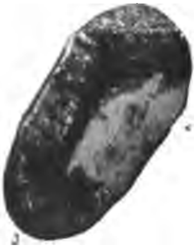

Fig. 5—Egg of *Pamera vincta*, from a photomicrograph, greatly enlarged.

NYMPHS.

First Stage.—Length of body, 1.75 mm. (.068 of an inch);

length of body and antennae, 3 mm. (.117 of an inch); length of head, .45 mm. (.017 of an inch) width of head, .46 mm. (.117 of an inch); width across prothorox, .5 mm. (.019 of an inch); width across third abdominal segment, .63 mm. (.024 of an inch).

In general shape the body is oblong, not depressed; head is somewhat triangular, slightly constricted behind the eyes; pronotum as seen from above, rectangular, about twice as wide as long; meso, and metanotum together about equal in area to pronotum and somewhat trapezoidal in shape; lateral margins of pronotum and mesonotum, and caudal margin of pronotum flattened into a narrow rim. Abdomen about three-fourths as long as head and thorox together. Antennae four jointed, excluding a very short, possible joint at base; first joint about two and one-half times as long as wide, sub-cylindrical in shape; second joint, .26 mm. in length, about equal in size and length to third joint; fourth joint somewhat longer than second, and spindle shaped. Numerous hairs are distributed quite evenly over the three distal joints, first joint sparsely haired.

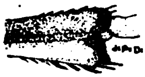

Fig. 6—Illustrating comb on tarsus of front leg of *Pamera vincta*, first stage. Enlarged·

The beak is distinctly four segmented; the third and fourth about equal length; the second is the longest, being .21 mm. in length; the first is three-fourths the length of the second.

Labrum is narrow and pointed, about two-thirds as long as first segment of sheath.

Clypeus protruding as a semi-ellipse; eyes large; no ocelli Legs well developed; femora of the first pair somewhat thickened, about one-fourth as thick as long, with tibia about same length as femora, becoming broader distally. On the distal end of each fore tibia, is a fine comb-like row of hairs, extending transversely across from a large terminal spine to the point of the attachment of the tarsus (see figure 6); on the distal third of the posterior aspect of each of these tibia are two rows of diverging spines, becoming stronger distally, and terminating on each end of the comb of fine hairs.

The tibia of the second pair of legs is about equal in length to a femora of that pair. In the third pair, the tibia is approximately a fourth longer than the femora of that pair. The tarsi are two jointed. In the first and second pairs, the distal joint is the longer; in the third pair, the joints are equal. In all of the tarsi the proximal joint is obliquely pointed, the distal joint is attached to the anterior, and proximal part of the oblique.

The claw is composed of two strongly curved hooks, set transverse to the length of the tarsus, and two bladder-like structures on stalks, extending distally from the base of each hook is a slightly curved bristle.

The body is sparsely covered with slender hairs; on the legs these become much thicker; on the distal portion of the tibia they are much larger, amounting almost to spines.

When first hatched the insect is rather uniformly bright red in color. This soon changes, and the general color becomes reddish brown with the red restricted mainly to the distal joints of the antennae, the proximal joint of the beak, the femora, and to the caudal part of the abdomen. On the dorsum of the abdomen, on each of what are probably the fourth and fifth segments, is a rectangular spot of a deep red color. There is a streak of red across the abdomen, on the caudal margin of the second segment. See figure 7, much enlarged.

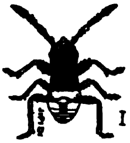

Fig. 7—*Pamera vincta*, first stage; hair line indicates natural length.

Second Stage.—Length of body 2.6 mm. (.101 of an inch); length of body and antennae 4. mm. (.156 of an inch); length of head .61 mm. (.023 of an inch); width of head .61 mm. (.023 of an inch); width of prothorox .75 mm. (.027 of an inch); width of body across third abdomen segment .96 mm. (.037 of an inch). Body oblong; head less constricted behind the eyes than in stage I. Antennae, beak, femora, tibiae and claws as in previous stage, except that the spines on posterior surface of tibia are larger, and are more nearly in rows, two rows on each tibia. The abdomen ends in a short fleshy protuberance. Color also much as in first stage, the bright red in distal segment of antennae becoming deeper, less red in abdomen; quadrate spots and band same color as before. See figure 8, much enlarged.

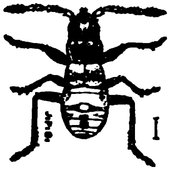

Fig. 8—*Pamera vincta*, second stage; hair line indicates natural length.

Third Stage.—Length of body 3.1 mm. (.12 of an inch); length of body and antennae 4.45 mm. (.173 of an inch); length of head .78 mm. (.31 of an inch); width of head .63 mm. (.24 of an inch); width across prothorox .7 mm. (.027 of an inch); width of third abdomen segment 1.16 mm. (.045 of an inch). Body rather oval in shape, proportionately narrower in front than formerly, the width of the prothorox being less than in the preceeding stage. Head somewhat longer than wide; there is a decided indentation on each side, where the antennae are attached. Clypeus, antennae and legs as previously described. Pronotum not quite as wide as long; no essential change in meso and metathorox. Beak reaching nearly to the middle coxae; tip clouded with black. General color brownish yellow; head deep brown; pronotum a shade lighter. Eyes a brownish black. Red markings as in previous stages. See figure 9, much enlarged.

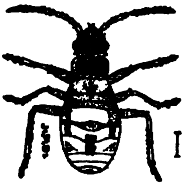

Fig. 9—*Pamera vincta*, third stage; hair line indicates natural length.

Fourth Stage.—Length of body 3.6 mm. (.14 of an inch); length of body and antennae, 5.83 mm. (.227 of an inch); length of head .83 mm. (.032 of an inch); width of head .78 mm. (.03 of an inch); width of prothorox .9 mm. (.035 of an inch); width of third abdominal segment 1.19 mm. (.046 of an inch). Body elongated, and becoming somewhat depressed. Wing pads plainly visible, the anterior pair being about one-half as long as mesonotum; both pairs extending nearly to caudal margin of first abdominal segment.

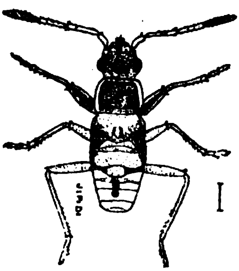

Fig. 10—*Pamera vincta*, fourth stage; hair line indicates natural length.

Distal segment of third pair of tarsi a fourth shorter than proximal segment. Quadrate markings on abdomen separated into five or six rectangles, by transverse lines. In other respects this stage is essentially as in the preceding. See figure 10, much enlarged.

Fifth, and Last Nymphal Stage.—Length of body 4. mm. (.156 of an inch); length of body and antennae 6.5 mm. (.253 of an inch); length of head .86 mm. (.033 of an inch); width of head .85 mm. (.033 of an inch); width of prothorox 1.08 mm. (.042 of an inch); width across third abdominal segment 1.4 mm. (.054 of an inch). Body elongated, depressed. Pronotum wider on caudal margin than on cephalic. Wing pads equal in length and reaching to transverse bar of red, on second abdominal segment.

First and second joints of beak equal in length; tip of fourth joint brownish black. Second joint of antennae longest. Femora of first pair of legs armed with six or seven strong spine like projections on posterior surface. Scutellum of mesothorox plainly outlined. Tarsi tipped with dusky. General color of body yellowish; head darkest; distal joints of antennae reddish purple. The six rectangular spots on abdomen alternately one red, and two black. See figure 11, much enlarged.

Adult Stage.—"Thorox constrained near the base, and with a transverse line before; hemelytra whitish with a fuscous spot.

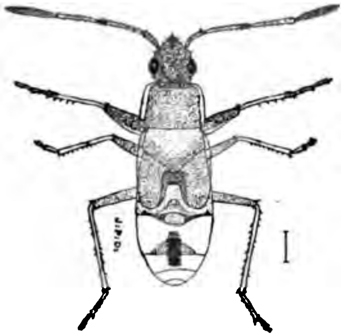

Fig. 11—*Pamera vincta*, **fifth stage; hair line indicates natural length.**

Body blackish, punctured; antennae, basal joint yellowish, tipped with black; remaining joints ———: thorox much constricted behind the middle, sub-cylindric, anterior margin with a tion; basal edge piceous; scutel; with a carinate line; hemelytra piceous; posterior margin of the stricture with a cinerious reflec-

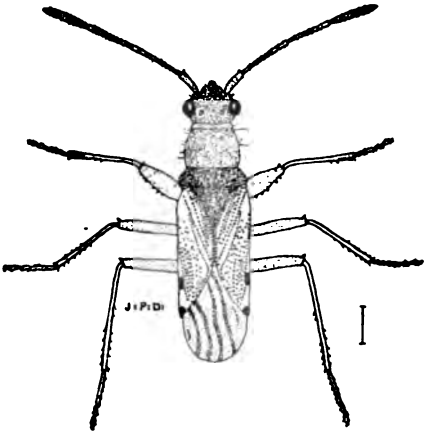

Fig. 12—*Pamera vincta*, **adult; hair line indicates natural length.**

transverse impressed line, anterior to which the margin is yellowish white and punctured on the corium, the posterior margin of which is fuscous; membrane milk white; abdomen on the margin dull rufous; feet whitish, thighs honey yellow, dilated. Length one-tenth of an inch.

Differs from contracta nob, in size, arrangement of colors, and by the distinct, impressed line before."—Thomas Say. See figure 12, illustrating an adult, and figure 13, illustrating a tarsus. Much enlarged.

All specimens of this species which I have examined differ from the above description in two or three particulars; the length will average about one-fifth of an inch, nearly twice that given by Say. However, there is much variation in length, the bodies of some males measure but 5-32 of an inch, while some of the longest females measure 5-16 of an inch. The membrane of hemelytra is much clouded with dusky above; below it is milk white. The feet are dusky. The claw and distal segment of each tarsus are blackish, the clouding extending upon the tibia; not whitish. The basal joint of the antennae is uniformly yellowish, there being no trace of black on distal portion.

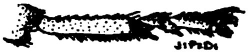

Fig. 13—Tarsus of *Pamera vincta.*

The antennae of an adult are very similar to that of the nymph. The first joint being short, about two and one-half times as long as thick; second, third and fourth joints are of about same length; second and third are cylindrical in shape; fourth joint is spindle shaped. First, second and third joints are uniformly yellow. Fourth joint rufous. Tarsi composed of three segments.

LIFE HISTORY OF THE INSECT.

In order that the insects might be kept under observation during their entire life cycle, twenty-five or thirty adults were captured from strawberry plants and brought into the laboratory. Several strawberry plants bearing green fruit were also brought in. On each of these plants a cluster of green fruit was inclosed in a large glass tube and loosely plugged at the bottom and top with cotton. Four to six adults were placed in each of these tubes. They soon became accustomed to their surroundings, and in the course of three or four hours were observed mating in two of the tubes. Two days from this date eggs were discovered down in the loose cotton at the bottom of these tubes. The eggs were placed in groups; probably the different groups were deposited by different females. In some groups the number of eggs was as low as six; in others, as many as twenty-five were counted. The egg state lasted eight days. When first deposited the eggs are uniform whitish in color. By the end of the third day the egg has a decided yellowish color; by the end of the fifth day this has changed to a bright red. From this date development seems to be quite rapid. The embryo becomes fairly well outlined in the course of another day. Early on the seventh day the embryo is distinctly outlined; the legs, antennae and beak can be made out with much certainty. From this time the red of the head and prothorox deepens to a reddish brown; the three basal joints of the antennae become clear yellowish; the legs become lighter.

During the eighth day of incubation fully two-thirds of the eggs in the two tubes hatched out, the skin of the egg breaking over the prothorox and head, and the insect gradually working itself free. After half an hour of quiet, the insects move slowly around for a while, and soon acquire considerable agility. Feeding begins usually, in the course of an hour or so.

During the first stage they probably do not occasion much harm to the berries. This stage lasts five days.

During the second stage, feeding continues about as before; they have gained in agility, and are easily disturbed from the fruit. The second stage lasts three days. The third also lasts three days. Habits and appearance similar to preceding stage.

By the fourth stage, the insect has become of sufficient size to be decidedly injurious to the fruit. They have now the general form of the adults. This stage continues during three days.

The fifth, and last nymphal stage is, as a whole, less active than the preceding stages. Feeding continues up to eight or ten hours before the last moult, when feeding ceases for the greater part, and the insects remain quiet. When disturbed they move reluctantly and slowly. In moulting into the adult stage, and in previous stages the skin splits longitudinally along the dorsum of the thorox, and the old skin is gradually worked off. Immediately after moulting, the colors are much lighter than normal. From the fifth stage the normal color of the adult is attained after twelve or fifteen hours. This stage lasts five days.

The length of life of the adult was not determined. Specimens were kept in a breeding cage twenty days, when they unfortunately escaped. Nor was it determined how soon after the adult stage is reached that egg laying begins, nor the total number of eggs that may be deposited by one female. It is seen from the above statements, however, that the life cycle from egg to adult, requires twenty-seven days.

THE INSECT IN THE FIELD.

The insects are probably overlooked by many, or are not regarded as of economic importance. To one standing naturally, they appear in the older stages, very much like the yellow ants that are so common in strawberry fields, and elsewhere. In many cases they are probably mistaken for these ants. By a more careful inspection, however, they are readily distinguished from ants by their less slender form, and by the less specialized body, the division of the head, thorox and abdomen being not nearly so well marked. And the insects remain more or less in hiding, preferring to remain under the heavy leaves of the plants, or in the surrounding mulching. It is very probable that a good many fields are quite badly infested with these insects, and their presence is not suspected, their injuries probably being attributed to other causes, or possibly not recognized to any extent. This insect cannot be regarded as a menace to strawberry growers, at least at present, but by its continuous feeding on the young fruit, frequently causing them to "button," it will, during a season, cause no inconsiderable loss.

The insects probably pass the winter in the strawberry fields, and during the coldest weather find protection among the dead leaves of the plants and mulching. Early in spring adults may be seen among the plants in considerable numbers; their activities are probably not suspended during our milder winters. In the course of a few weeks young in various stages of development are to be seen. By the time that the earlier and more valuable fruits has begun to form, the insects are abundant enough to cause some destruction. As the season advances they become much more numerous, and their injuries are consequently increased.

Fields a year or two old are very naturally, not so badly infested as older ones. The usual custom of mulching offers these insects good protection, and an excellent breeding place.

By the first of March of the present year these insects were quite abundant in the fields, in all stages, here at Lake City. In more southern parts of the State, they may begin breeding earlier; possibly breeding continues throughout the winter where food is abundant. Although these insects have been frequently observed feeding on the leaf stalks of the plant, yet it would seem that these do not furnish a good substitute for the fruit. After "running" begins and the formation of fruit ceases, they are much less abundant, than when fruit was abundant.

Enough adults, however, may usually be found among the plants to infest them the next season. The adults fly readily during the warmer part of the day, and possibly pass from one field to another. At this date, July 15th, they are abundant in the plats of late varieties, which are still fruiting, on the Experiment Station. In fields where Newnan and Cloud varieties are planted, whose fruiting has ceased, they are not nearly so abundant.

I have not been able to discover other food plants of this insect than the strawberry. The insect seems to be indigenous, and it is probable that its preference for the strawberry is an acquired one. A near relative of this insect, Pamera longula, Dallas, I have frequently swept from oats and various other grasses, and have observed them in various stages feeding on the involucre of the Sand-spur (Cenchrus echinatus).

Pamera vincta, in the field, is very agile, and not at all easy to capture. To observe them in their natural mode of living, one must approach the plant carefully, and look down among the leaves on the ground around the fruit clusters. Usually a considerable number may be seen on the fruit with their beaks stuck down into it, sucking up the juice for food; others may be standing quietly by, or walking slowly here and there. Upwards of fifty of these insects, in various stages of development, have been counted around a single plant. A slight disturbance of the plant, less than that caused by picking the fruit, causes a panic among them, and the older ones dart here and there to hide. Where plants are mulched, they have no trouble in finding protection. Where there is no mulching, they may run out from the protection of the plant, and the adults fly away. The older nymphs usually run off to neighboring plants. The younger nymphs do not leave the immediate neighborhood of the plant, but find protection amongst the dead leaves of the plant, on the ground.

HOW TO BEST CONTROL THE INSECT.

From the foregoing it will be seen that this insect will be rather difficult to successfully combat. From the fact that they obtain their food by sucking, the arsenical compounds that kill by being eaten with the food, will be of no use. An insecticide must be used that kills by contact, or that poisons the air breathed by the insect. The great agility of these insects makes the application of such insecticides as these only partially effective, particularly with respect to the adults. However, a good contact insecticide may be used with advantage during the cooler weather of the spring, or in early morning, or late in the evening. At these times they are not nearly so quick to escape as during mid-day, the adults rarely taking flight. Kerosene emulsion is a good insecticide against these insects, and is particularly effestive against the younger nymphs. If used thoroughly, in the spring, and during the cooler portion of the day it will probably keep them well in check.

There is, however, an objection to the use of kerosene emulsion during the fruiting season, and that is, that it taints the fruit upon which it has been sprayed. This is a serious objection to its use during the fruiting season of the plants, and if the insects cannot be gotten well in check before fruit begins to ripen, another insecticide should be used. The most satisfactory insecticide among those tested, that could be safely used during the fruiting season, is the Rose Leaf Insecticide, previously referred to.

This insecticide was used in the proportion of one pint to six gallons of water and was thoroughly applied with a knapsack sprayer. The young were killed quickly by it; adults are not so susceptible possibly from the fact that their agility enables them to escape thorough spraying. However, the insects can probably be kept in check by this destruction of the young. In applying this insecticide, and all others, it should be done with a good spray pump of some kind, and applied thoroughly. The leaves of each plant should be moved around during the operation of spraying, so that the ground beneath may be thoroughly sprayed.

Spraying should be repeated at intervals of ten or twelve days, until the insects are destroyed.

This insecticide may be readily washed from the fruit, and does not seem to leave any taste, or injurious effects.

THE TARNISHED PLANT-BUG. (Lygus lineolaris, Beauv.)

Order, Hemiptera. Family Capsidae.

The injuries of the tarnished plant-bug are by no means confined to the strawberry plant. Indeed, but few species of insects enjoy a wider range of food plant, than does this small Capsid. It is to be found in Florida on almost all varieties of garden produce, and on various field crops as well. Like all Hemipterous insects, it feeds by sucking up sap from plants with its beak, and when quite numerous, serious damage is occasioned.

Injuries to strawberries, consists in puncturing the leaves, tender shoots, and in sucking juice from the young green berries. This attack on the berries, if very severe, causes them to blacken and die. In less severe cases the fruit "buttons," much as in the case of the strawberry Pamera.

While this insect cannot now be said to be a serious drawback to strawberry growers in Florida, yet it must be carefully watched in that it has been known to cause much damage to strawberry growers in the North. Should the particular conditions that best favor its development occur in our State, we might expect it to become a serious pest.

Dry seasons, such as the spring that has just passed, are favorable to its development, and it is during such seasons, that its ravages will be most felt. Aside from this dry condition of the air and soil, which retards the development of the fungous enemies of the insect, the plant infested shows the effect of an attack more quickly, in that respiration is greater, and the water supply less, and it is consequently less able to suffer the drain upon its sap.

Dr. S. A. Forbes, records one instance* where this insect, during one season, occasioned a loss of between five and ten thousand dollars to an extensive strawberry grower in Illinois. In this case the damage was occasioned by the insects attacking the green berries, piercing and sucking the juice from them, which caused the berries to wither, and blacken. The above indication of its destructiveness, well emphasizes the necessity of keeping a close watch on this pest in Florida.

APPEARANCE OF THE ADULT.

The adult tarnished plant-bug is illustrated in figure 14, D considerably enlarged. The small hair line to the right indicates approximately its natural length. As seen from the hair line it is about one fourth of an inch in length; it is about twice as long as broad. The body is elliptical in shape, and somewhat flattened. There is much variation in color, varying from a rather uniform brown to a light yellow. The usual markings may be almost entirely absent. More commonly, however, the insects are yellwish brown in general color, with the prothorax margined with yellow, and with several yellow longitudinal lines across it; on the scuttellum is a yellowish shaped mark and there is a dark patch on the distal portion of the corium.

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*Thirteenth Report on the Noxious and Beneficial Insects of the State of Illinois, pg. 124.

LIFE HISTORY AND HABITS.

Adults appear early in spring among the various plants which they infest. It seems very probable that the winter is passed in the adult condition. In the North, both adults and nymphs pass the winter under rubbish and trash, or almost any place that will afford them the desired protection. This mode of passing the winter is probably followed by these insects in Florida.

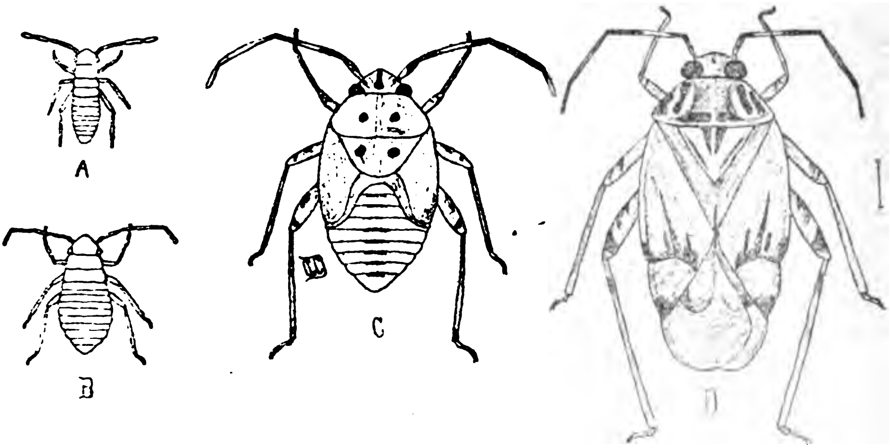

Fig. 14—*Lygus lineolaris:* A, first stage; B, second stage; C, fourth stage; D, adult, all much inlarged. (After Davis.)

On the Horticultural grounds of the Station, these insects have been observed in considerable abundance during early spring, in the St. Augustine grass growing on the slopes of the terraces. It is probable that many pass the winter in the dried up grass along these terraces.

After the appearance of adults in spring, eggs are soon deposited on the food plant, and before long young and adults may be seen feeding together. After hatching from the egg, the young pass through four stages before arriving at the adult condition. Soon after hatching from the egg they are sulphur yellow, or pale green in color, measuring about one-twentieth of an inch in length. Figure 14, A.

During the second stage they are about one-twelfth of an inch in length, with about the same general color as in stage I. A black quadrangular spot is found on the dorsum of the abdomen. On the thorax are four circular black spots, varying much in the degree of intensity. See figure 14, B.

The third stage differs from the second mainly in size; the length now being about one-eighth of an inch. Wing-pads begin to appear as slight prolongations, from the meso and metathorax.

In the fourth or pupal stage, the wing-pads are considerably elongated, reaching quite to the fourth abdominal segment. The length is now about one-eighth of an inch, the breadth averaging about one-twelfth of an inch. In this stage the body is markedly broader than in preceeding stages. Figure 14, C.

Several broods are probably raised each season. Young may be observed as early as March, and throughout the summer until November. This long breeding season allows of three or four broods each year, and possibly more.

The insects, both young and old, are quite agile, readily hiding among the heavy leaves of the strawberry or other plants that they infest, thus frequently escaping the notice of the grower entirely. They are less agile during the cooler mornings of early spring, and may be destroyed much easier at this time, than during the warmer part of the day, or later in the season.

HOW TREATED.

The use of contact insecticides against this insect is not very satisfactory, as may be judged from their habits, in that they are quite active, particularly during the warmer weather. However, if the application be made during early spring when the weather is still cool, considerable may be accomplished with contact insecticides.

Dr. Forbes of the Illinois Experiment Station, who has given this species considerable study, has found that pyrethrum powder, applied either diluted with flour, or suspended in water makes an efficient remedy. This should be thoroughly dusted or sprayed on the plants infested, preferably during the cooler portion of the day. If the dry powder is to be used, it should be diluted with eight or ten parts of cheap flour, and dusted on while the dew is on the plants. When it is desired to apply the powder with a spray pump, it should be thoroughly mixed with water at the rate of one ounce to four gallons of water.

Kerosene emulsion is also effective, and can be used safely before, or after the fruiting season has passed.

The "Rose Leaf" insecticide, previously referred to was not tried against this insect. It would probably be of value, applied as for the strawberry Pamera. It may be applied during the fruiting season without detriment to the ripe fruit. One pint to six gallons of water would probably be about the right strength.

THE LEAF-FOOTED PLANT BUG.

(Leptoglossus phyllopus, Linn.) Order Hemiptera. Family Coreidae.

The leaf-footed plant bug not unfrequently attacks the strawberry. In early spring the adult may sometimes be observed sucking the fruit and tender shoots. They are capable of doing considerable damage in this way. Probably they occasion most serious harm by sticking their beaks in the young fruit, which frequently withers and blackens from the attack. They have been reported as attacking the blossoms of the strawberry; this is not at all improbable; however, the writer has never observed them doing so.

The usual food plant of this insect in Florida seems to be a species of thistle, (Carduus spinosissimus). On this plant the insect breeds, and the young and old may be seen clustered around the heads, sucking juice from the plant. The young are confined mainly to this, and similar plants, and do not, as a rule, attack garden crops.

However, nymphs were observed during the fall of '96, on the vines of the Irish potato, where it would seem that they had developed from eggs. The young, not being winged, are confined to the immediate neighborhood of their birth. The adults, however, during the warmer part of the day, are quite active, and fly readily from place to place. Figure 15 illustrates an adult of this insect, from a photograph, enlarged about two-thirds.

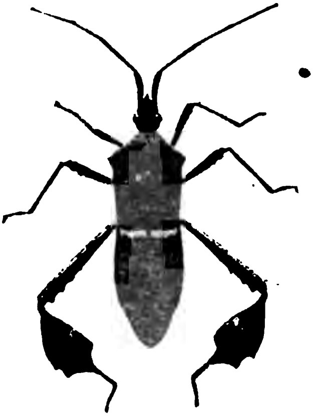

Fig. 1 —*Leptoglossus phyllopus;* adult from a photograph, enlarged about two-thirds.

HOW BEST CONTROLLED.

From what has been said, it is evident that an excellent preventive measure would be the destruction of the plant upon which they breed. Where the insects are troublesome it would be well to carefully look around for these thistles and destroy them, and the young insects infesting them.

Mr. H. G. Hubbard, in "Insects Affecting the Orange" states that a single large patch of thistles has been known to infest a wide area, but that when these were cut down and destroyed, the bugs in time disappeared from the groves in the neighborhood, and gave no further trouble. This statement will illustrate the importance of attending to these thistles.

The insect may be kept in check very profitably by picking them from the plants by hand. This is only practicable during cool, cloudy weather, when the agility of the insect is much lessened. Where the thistles, upon which this insect breeds, are kept down, there is usually no occasion for further measures against it.

THE NEGRO BUG.

(Corimelaena pulicaria, Germ.) Order Hemiptera. Family Corimelaenidae.

This is a small, black bug infesting strawberries, blackberries, raspberries and other fruit. In Michigan it has been reported as very destructive to celery. It enjoys a wide distribution over the U. S. and Canada. In this State it is probably more abundant on blackberries than other fruit; but strawberries are frequently badly infested.

The injury of this insect to strawberries and blackberries is due mainly to the strong bed-bug odor which it imparts to berries with which it comes in contact. A great many of us know by experience of the nauseous flavor imparted to fruit by this pest. Although the culprit may have left the fruit for some time, his tell-tale odor renders the berry unfit for eating.

Where a field is badly infested by this insect, the market value of the fruit is greatly lessened, by the odor which it imparts to the berries. Aside from injury to the fruit in this way, this insect occasions considerable damage by sucking the berries and stems.

Mr. F. M. Webster has made some observations on this insect in captivity. In the latitude of Indiana, adults confined on wheat under glass, and fed on ripe strawberries, began ovipositing May 20th. The eggs were placed singly on the leaves, and sheath of the grain. The eggs are elongate-oval in shape, about .6x.4 mm. in length and breadth respectively and are of a very light orange color when deposited, changing to a livid red as the embryo becomes nearly developed. The egg state lasts sixteen days The first larva, or nymph measures .6 mm. in length; legs yellow, body brown anteriorly, barred with brown posteriorly.

The adult is black, with a white stripe on each side; the body is short, broad, and somewhat convex above. It is about an eighth of an inch in length. Figure 16 illustrates the insect,

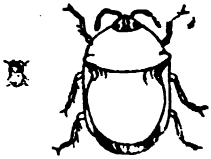

Fig. 16—*Corimelaena pulicaria;* natural size and enlarged. (After Riley.)

natural size, and much enlarged in outline. The "scutel" or shield is greatly developed, in all members of this family, covering the entire dorsum of the abdomen.

HOW CONTROLLED.

Mr. G. C. Davis of the Michigan Station has made a number of experiments with insecticides and repellants against this insect.* As the result of these experiments he finds that the use of a spray of crude carbolic acid, mixed with water in the proportion of a tablespoonful of the former to two gallons of the latter, was a very effective repellant against them in celery fields. They were driven and scattered by the offensive odor of the acid.

Mr. Davis also used air slacked lime and plaster, impregnated with the odor of the acid. A teacupful of acid was added to a bushel of lime, or to the plaster. This was sprinkled over the plants, and was found to retain the odor longer than in the case of the spray, although not so strong.

These repellants would probably be of much value in keeping this insect away from the strawberry or other plants. There is possibly some objection to its use on ripe strawberries that are to be picked soon after its application. However, when a field has become badly infested, it would be economy to thoroughly spray the field, and not to pick the berries for one or two days thereafter. This would give time for the odor to quite disappear from the fruit, and the insects would probably not return in much severity. There need be no fears that poisoning might result from eating berries so treated; the usual washing of the fruit would probably do much to remove all trace of the acid, even if picked soon after having been sprayed.

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*Bulletin No. 102, Michigan Agricultural Experiment Station.

Hot water was also used, and seemed to be very effective in killing the bugs. Water heated to a temperature of 155 degrees F. was found to kill the bugs, while the celery plants could stand water at a temperature of 175 degrees F. The use of hot water would probably be practicable in fighting this insect on strawberries.

CUT-WORMS.

Under this name are to be included larvae of several different species of Noctuid moths. Cut-worms are usually naked, or but slightly hairy, of a dark color, ranging from an inch to an inch and one-half in length. Cut-worms as a rule live in the soil during the day time, and at night come out to feed. They attack various plants, usually near the ground, or at times climb upon the plants, eating the tender stalks and buds. In this way from their usual abundance, they occasion serious trouble.

In the strawberry field, cut worms are frequently very abundant and destructive. Frequent letters have come to the Experiment Station regarding them. One grower wrote that he dug out on an average of 600 daily, for a period of a week, and finally gave up the fight. Another grower reports that he has found as many as forty near a single plant. These might be regarded as rather extreme cases, but it is well to recognize the fact, that cut-worms are usually sufficiently abundant in the fall and spring in this State, to warrant our recognizing them as serious pests.

Our more common and injurious cut-worms are larvae of moths belong mainly to the genera Agrotis, Mamestra and Hadena. The most abundant and serious cut-worm to the strawberry in this locality seems to be the larvae of Agrotis ypsilon, or the greasy cut-worm. This species has been particularly abundant during the late fall and spring just passed.

Nearly full grown larvae of this species were placed in breeding cases November 24th. These were fed until December 12th, when they began pupating. In a few days all had pupated. On January 23rd forty-two days later, the first moth appeared. In five days, all pupae had changed to adults. These were furnished with plants to induce oviposition, but this was not observed nor were any eggs discovered. The adults died in three or four days after emerging from the pupae. Adults of this species were by far the most common Noctuid at electric lights during the spring, and judging from their abundance, we may expect trouble from the larvae during the fall.

LIFE HISTORY OF CUT-WORMS.

The following general statements regarding the history of cut-worms, is applicable to most of our common species. Eggs are deposited by the female soon after their emergence from the pupa state, quite low down on the leaves or stems of various species of plants. Upon hatching, the young larvae descend to the soil, and feed on the tender portions of herbaceous plants. They grow comparatively slow for caterpillars; larvae hatched in the spring probably become full grown by late fall, and during the latter part of their life, their ravages are much more severe.

During mild winters larvae of Agrostis ypsilon have been taken of various sizes from early fall until late spring, and it seems probable that there is but little regularity as to the time of appearance of the adults. Many larvae pass the winter buried beneath the soil; in some cases, as in Agrotis ypsilon, the winter may be passed in the pupa state.

APPEARANCE OF A CUT-WORM.

The greasy cut-worm, the larva of Agrotis ypsilon, Hufn. from its abundance in Florida, is here described. A full grown larva is usually about an inch and one-half in length, body rather stout and plump. Its general color is a brown, or a dull gray, varying to lighter. The head is darker than the body, and darker above than below, tips of mandibles black. Just behind the head, on the first segment of the thorax is a shield, dark brown in color about covering the dorsal surface of this segment.

There is much variation in the markings, but usually there are two pale lines extending down along the back. Along each side are eight small black spots, the spiracles or breathing pores. A few slender hairs are distributed over the body, arising mainly from small, black or brownish colored spots. Figure 17 a, represents the larva of Agrotis saucia, another common cut-worm in Florida.

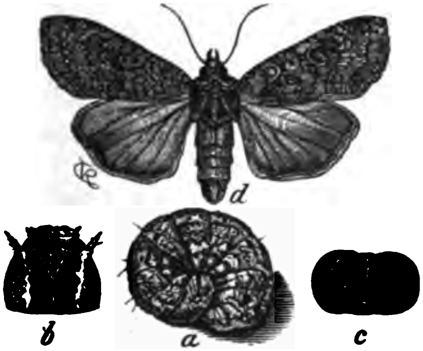

Fig. 17—*Agrotis saucia;* a. larva; d, adult; (Riley, U. S. Dept. Agriculture Annual Report 1884.)

APPEARANCE OF THE MOTH.

The body and head are a little less than three-fourths of an inch in length. From the head to the tip of folded wings is seven-eighths of an inch. Wings expand nearly two inches. Above, the insect is dark brown in general color; on the thorax below whitish; on the abdomen below, gray, darker on the sides; the abdomen terminates in a small bunch of yellowish hairs. The front wings have usually certain quite distinct and constant markings, of lighter color. The hind pair are white, margined with dusky. Figure 17 d, illustrating the adult of Agrotis saucia, gives an idea of the general appearance of one of the cut-worm moths.

TREATMENT.

Various remedies are recommended against cut-worms. Some of these are of value; others do not seem to give much relief. The use of poisoned bait, has probably proven to be the most satisfactory remedy thus far advocated. Dr. Riley was first, I believe, to recommend the use of poisoned cabbage leaves against cabbage cut-worms. The leaves were poisoned by dipping them in water with which Paris green had been mixed. These were placed around promiscuously in the field a week or ten days before the field was to be planted, and even after plants were planted.

Of late years, poisoned bran has come into more general use, probably from the fact that it is much more accessible, and convenient to apply.

Mr. F. A. Sirrine* of the Geneva Station, has recently reported some interesting experiments with insecticides against the onion cut-worm. As a result of these experiments, he has found that dry bran poisoned with Paris green gives the best results against this insect. The dry bran bait is preferable to the wet bait in that it is much easier to apply, and does not harden or mould so quickly and hence become worthless as bait. Furthermore, the dry bait may be applied much more uniformly. With this it is possible to drill it with a seed drill along each side of a row. In some cases the insects seemed to prefer this bait to their usual food. As a rule, cut-worms are quite general feeders, with feeding habits essentially the same; and we might expect to be able to treat the strawberry, and other cut-worms in Florida quite successfully with this bait of dry bran poisoned with Paris green. The bait is made by thoroughly mixing one part by weight of Paris green to fifty parts of bran. This bait should be drilled or sprinkled along the rows quite early in the spring, even before the presence of cut-worms is noticed to any extent. It would be an advantage to have destroyed the cut-worms before

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***Bulletin No. 120, New York Agricultural Experiment Station.**

ripening of fruit begins, although there is but little danger of poisoning, if the bait has been carefully applied.

Cut-worms frequently migrate from the herbage and grass surrounding fields, to the plants within, and in a short while may bring about their destruction. In such cases, the use of dry bait scattered around the field would probably be of considerable value.

THE COMMON WHITE GRUBS.

(Lachnosterna spp.) Order Coleoptera. Family Scarabidae.

There are a number of different species of insects which in the larval state attack the roots of the strawberry plant. Probably larvae of the above genus are responsible for a considerable part of this damage in this State. These larvae are familiarly known as "grubs" and are very frequently plowed up during the cultivation of various crops, particularly on new land. These larvae pass their entire life under ground, feeding on the roots of plants.

The fibrous roots of grasses probably furnish a considerable part of their food, but they are known to attack the roots of many other plants. Corn frequently suffers severely. The roots are frequently eaten off within a few inches of the stalk. Whole fields of corn have been destroyed in this way, particularly on new land. Potatoes are at times attacked, and holes eaten in them. The grass on lawns and pasture lands are frequently severely attacked at the roots by these insects, large areas turning brown and drying up.

Injury to the strawberry and other similar plants consists in the destruction of the fibrous and main roots, and if the larvae are somewhat numerous the death of the plant will eventually result.

APPEARANCE OF THE GRUB.

Figure 18, 2, represents a larva of one of the most common of these insects (Lachnosterna fusca) in its earthern cell feeding upon the roots of some plant.

It is a large, white, soft grub, sparsely haired, with a light mahogony colored head. There are three well developed pairs of nearly the whole length of the body. This is the alimentary than anteriorly. When unearthed, the insect usually assumes a curled up shape, the head and caudal end nearly touching.

There is another grub somewhat similar in appearance, which is sometimes quite abundant in manure, or compost heaps. This grub feeds exclusively on decaying vegetable matter and manure, and should not be confounded with the injurious grubs which feed on live vegetation. In the manure feeding larva a dark line may usually be seen extending down the dorsum, for nearly the whole length of the body. This is the alimentory canal, filled with black vegetable matter, their food. In root eating grubs this black line is usually not to be observed, except near the caudal end, since their food, being light colored rootlets, is not so apparent through the whitish body.

THE ADULT.

Beetles of the genus Lachnosterna may be recognized trom 3 and 4, figure 18, which represents adults of fusca. This species is of a brownish color, lighter below and deeper above. Head almost black. The body is oblong-oval, somewhat convex, measuring about three-fourths of an inch in length, though the size varies considerably. On the ventral surface of the thorax is a patch of light yellowish, silky hairs. There is also a fringe of hairs of the same color on the dorsum, apparently born by the posterior margin of the prothorax.

The adults are usually known as May beetles, June bugs, or cock-chafers. They fly mostly late in the evening, and at night. In the evenings they are sometimes seen in myriads flying around oak and other trees. In this stage they are not destructive to the strawberry, but feed mostly on the foliage of forest or orchard trees. Their injuries in this stage are sometimes quite severe. Being readily attracted by lights they not unfrequently find their way into lighted rooms, and fly around here and there thumping against the wall.

LIFE HISTORY.

The life histories of insects of this genus are not well known. In the case of fusca, the larval stage has been said to last about three years, but more recent observations indicate that it is probably not so long. This time is passed in the earth feeding upon the roots of plants. When ready for pupation an ovoid chamber is constructed, lined with a gelatinous substance, and the larva changes to a pupa. (Figure 18, 1.)

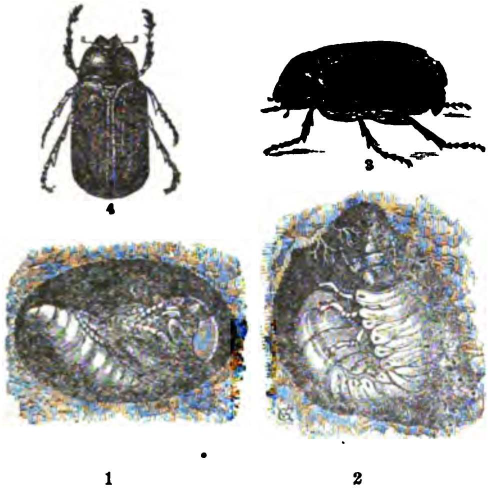


Fig. 18—*Lachnosterna fusca;* 1, pupa; 2, larva; 3 and 4, adult. (After Riley.)

The adult soon developes from the pupa; at first it is white, and soft, but gradually becomes harder until the normal condition is reached, when the beetle escapes from the earth. In ovipositing, the females are said to creep into the earth, especially where it is soft, and deposit forty or fifty white, translucent eggs. Soon after oviposition, death occurs. The egg state lasts about one month.

SUGGESTIONS FOR TREATMENT.

The strawberry grower will be interested mainly in the destruction of the larvae, since the adults do not injure his plants, but a wholesale destruction of adults would result of course, in materially lessening the number of larvae in the future.

In fields where the presence of the grubs is manfest from a withering of the plants, much can be done by digging them out from the affected plants and destroying them. This precedure would hardly be profitable perhaps, except in the case of valuable crops.

Flowers of sulphur has been used with considerable success as a repellant. It should be thoroughly mixed in the soil around the infested plants. The use of gas lime has also been found of value. It should beapplied thicklyto the surface of the soil four or five weeks before the field is to be planted to strawberry or other plants. It should be thoroughly worked in the soil by plowing.

This dressing is said to be of much value in destroying the grubs in new land, and in land that has been devoted to pastures for some time. The lime should not be used fresh, as thrown out from the gas factories as at this time it is fatal to vegetation. On exposure to the air, however, it looses its injurious qualities, and becomes a fertilizer of some value, as well as a remedy for the grubs.

Fall plowing and harrowing in fields that are to be planted to strawberries, will be of value. Barnyard fowls should be encouraged to follow the plow, so that they may destroy the unearthed grubs.

THE STRAWBERRY FLEA BEETLE.

(Haltica ignita, Illiger.) Order Coleoptera. Family Chrysomelidae.

The strawberry flea beetle has been reported at times as quite destructive to the leaves of the strawberry plant in Florida. In bulletin No. 9 of this station, Dr. J. C. Neal, states that this insect has been a source of much trouble to strawberry growers, and has been frequently sent in from various parts of the State.

The insect seems to have been very bad at Orlando, during the spring of 1890, judging from a letter written to the Entomological Department at Washington, by Mr. W. E. Hudson, and published in "Insect Life." Vol. II, Nos. 11 and 12; pg. 367. In this letter he states that the beetles appeared on his strawberry plants by thousands, and that all the berry fields in the neighborhood were infested. They were also observed on different species of weeds, and on peach trees.

This insect, like its near relatives, the grape-vine flea beetle, and the cucumber flea beetle, feeds on the leaves of plants, eating holes in them, and when numerous would probably quite defoliate the plants. They are small beetles, about a fifth of an inch in length, of a bronzy yellowish color. The femora of the third pair of legs are greatly thickened, enabling them to jump with agility, somewhat like fleas.

The life history of the insect has not, I believe, been made a subject of thorough study. It has not been observed by the writer at Lake City, and hence it has not been practicable to undertake the study of its life history.

In the case of one of its near relatives the grape-vine flea beetle, the eggs are placed in clusters on the under surface of the leaves. The larvae hatching from these, feed on the young leaves for about a month, and then enter the ground and change into pupae, emerging in about a month as adults. The second brood also attacks the leaves of the grape-vine, but they are not nearly so destructive as the previous brood. The winter is probably passed in hybernation.

Possibly the life history of the strawberry flea beetle is somewhat similar to that of the grape-vine flea beetle. There seems to be no record, however, of observations of the larvae feeding on the leaves of strawberry plants, and it is possible that they live beneath the ground feeding upon the roots of plants, upon the leaves of which the adults feed, as is the case with the cabbage flea beetle.

Until the life history of the insect is known in detail, it will not be possible to more than indicate treatment against the adult. The use of an arsenical spray would probably be quite sufficient to destroy these insects, but there are objections to the use of arsenites on strawberry plants during the fruiting season, from a possible danger of poisoning the fruit. This insecticide could be used safely before and after the fruiting season.

Probably the following formula would be quite efficient:

Paris green	½ pound
Powdered, or quick lime	½ pound
Water	25 gallon

The lime should be made into a thin paint with water, and strained into the mixture of water and Paris green. Unless the lime is used, where the proportion of Paris green is so large, scalding of the plants may result.

For the treatment of this insect during the fruiting season of the plants, it has been recommended to dust air-slacked lime, or tobacco dust freely over the plants. These substances act as repellants, and are said to have considerable value against this and other flea-beetles.

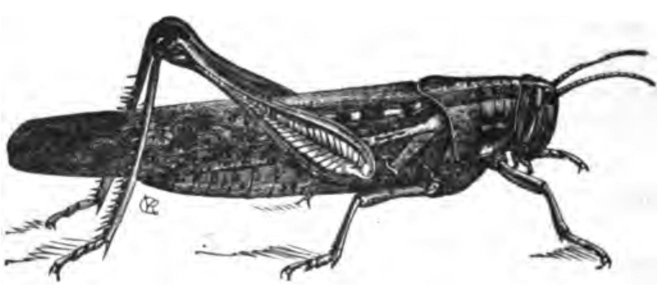


Fig. 19—*Schistocerca americana;* adult. (Riley, U. S. Dept. Agri'l.)

GRASSHOPPERS.

Several species of grasshoppers eat the leaves of the strawberry plant. When abundant they are capable of doing considerable damage.

Figure 19 represents our common large American locust, Schistocerca americana. This species is occasionally of considerable trouble in strawberry fields.

Figure 20 illustrates another common grasshopper, (Caloptenus femur-rubrum) in Florida, and sometimes a serious pest to strawberry growers.

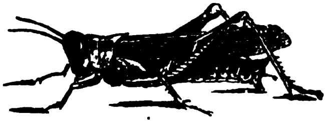


Fig. 20—*Caloptenus femur-rubrum;* adult. (Riley, U. S. Dept. Agri'l.)

All of these different species can probably be treated successfully in the same way. The use of poisoned bait is probably the most satisfactory way of treating them. To a quantity of bran add enough Paris green to give it a greenish tinge, and add molasses to sweeten it. This bait should be placed here and there in the field in small heaps. Care should be exercised in its use

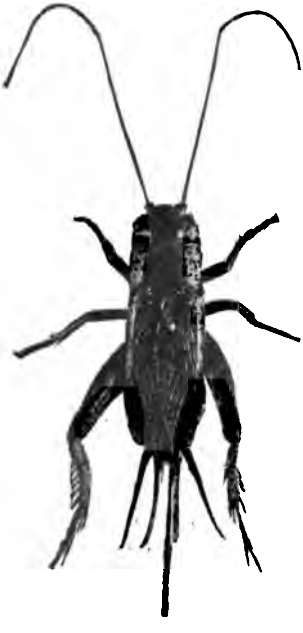


Fig. 21—*Gryllus assimilis;* adult female, from a photograph, enlarged about two-thirds.

that it is not gotten on the plants, from the possibility of poisoning the berries.

FIELD CRICKET.

(Gryllus assimilis.) Order Orthoptera. Family Gryllidae.

Figure 21 illustrates a common insect in the strawberry field, and one which has been accused of doing considerable damage to the ripened fruit. Notwithstanding their frequent abundance, probably but few growers have ever actually seen them feeding on strawberries.

From the shyness and alertness of these insects, they can rarely be approached unawares, and studied in their normal mode of living. Examinations of many different plants from which crickets have been frightened, lead me to believe that the cricket must undoubtedly be classed as an enemy to the strawberry grower. In the majority of cases where crickets were frightened from plants, much of the ripe fruit had been eaten into in such a way that decay would soon result. A hole, an eighth of an inch deep or more is sometimes eaten into the fruit, but more usually several smaller pits are eaten out. If an individual cricket were to confine its attention to one berry, the damage would not be so great, but it does not seem to do this, but attacks several different berries. In this way a single insect is able to occasion the destruction of a considerable number of ripe fruit in a short while. The heavy leaves of the plant, and the mulching, afford them excellent protection, and unless disturbed they rarely leave these places during the day.

Probably two or three different species of crickets are destructive to strawberries in this State, but the one illustrated, seems to be the most common and injurious. The young, as well as adults, are capable of injuring the fruit.

TREATMENT.

Probably a bait of poisoned bran, sweetened with syrup, would be of value in destroying these insects. The bait should be placed in small quantities along the infested rows. Much could be done by frightening the insects from the plants and destroying them with a suitable stick, or brush.

THE STRAWBERRY WEEVIL.

This is a small snout-beetle measuring about one-tenth of an inch in length. The beetle varies in color from a dull red to nearly black. On each wing cover is a dark spot, surrounded with fine whitish hairs. The injuries of the insect consists in cutting the pedicel of the young buds in such a way that they will fall over, much as if broken, or in some cases cutting off the pedicel entirely.

This injury is occasioned by the insect, in order that further development of the bud may be arrested, thus protecting the eggs which the female deposits within the unopened bloom. The young grubs feed upon the pollen within the bud, and when this is exhausted, attack other parts. The grub matures within three or four weeks, and the pupa state is entered, within the bud. This state lasts from five to eight days. Only pollen bearing flowers are attacked, as the larvae are essentially pollen feeders.

In many parts of the United States, this insect occasions considerable damage. I do not know that it has been reported from Florida, but it is here mentioned in order that growers may be on the lookout for it.

THE STRAWBERRY CROWN-BORER.
(Tyloderma fragariae, Riley.)

This is another snout-beetle that in some parts of the United States is a source of anoyance to strawberry growers. The writer has not yet met with this insect in Florida.

The eggs are deposited on the plants by the adult females. The grubs hatching from these, mine into the crowns of plants. When full grown they are about one-fifth of an inch in length, white, with pale yellow heads. They change to the pupa state in the burrows made in the crowns, and after changing to the adult, usually remain in the crown for some time. The beetles are brown in color; on each wing cover are several poorly defined black spots.

But one brood is raised each year. The insects are more common in old, than new strawberry patches.

THE STRAWBERRY LEAF-ROLLER.

(Phoxopteris comptana, Frohl.)

The strawberry leaf-roller has not as yet been reported to the Experiment Station from Florida. If it occurs within the State, it is probably not yet very severe. It occurs throughout the northern United States, where it is regarded as a very destructive insect. Observations on the distribution of this insect for several years past indicate that it is making its way southward. I have not been able to determine its southern limit at the present date. In 1890 it was an abundant insect in Kentucky.

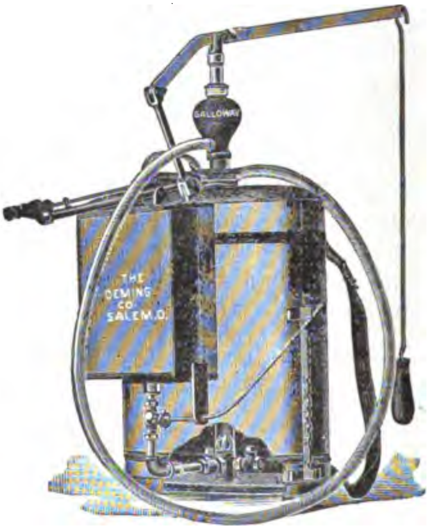


Fig. 22.

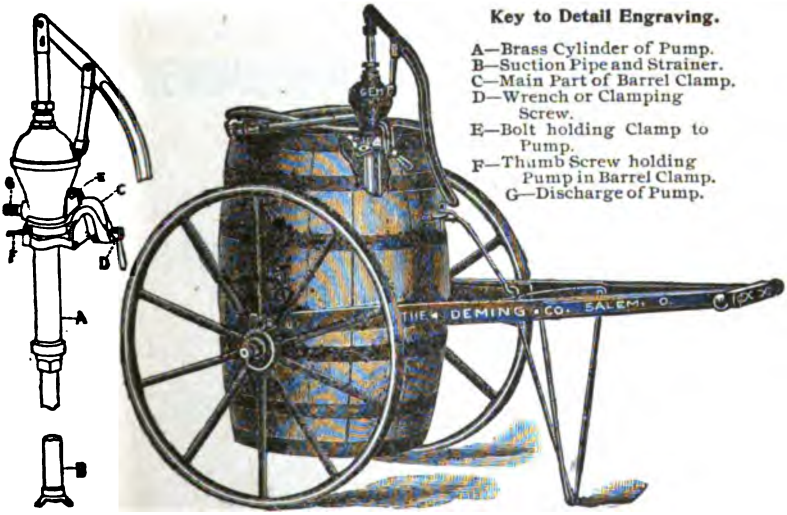
Larvae of this insect are leaf-rollers, or folders as the common name indicates. Upon hatching from the egg, a larva begins folding the leaves together, and fastening them with silk. The caterpiller spends its life in this retreat, eating the leaves, eventually causing them to turn brown and die. The pupa state is passed within the folded leaves.

The moth is small, measuring about one-half of an inch across the wings, is of a brown color, and obscurely marked. Two broods are recorded for this insect annually, in the North. According to Prof. Garman, at least three broods are raised each year in Kentucky.

SPRAYING MACHINERY.

The use of some form of spraying machinery is absolutely necessary for the proper application of insecticides or fungicides.

A convenient and serviceable sprayer is to be found in the Knapsack spray pump illustrated in figure 22. This sprayer may be swung on the back, and the application of the insecticide or fungicide accomplished by one person. The kerosene attachment, illustrated in the figure, is designed for the mixing of kerosene and water while in the act of spraying. This attachment may be removed when it is not desired to use it for this purpose.


E
C
F
D
A
B
GEM
THE DEMING CO. SALEM, O.

Key to Detail Engraving.

A—Brass Cylinder of Pump.
B—Suction Pipe and Strainer.
C—Main Part of Barrel Clamp.
D—Wrench or Clamping Screw.
E—Bolt holding Clamp to Pump.
F—Thumb Screw holding Pump in Barrel Clamp.
G—Discharge of Pump.

Fig. 23.

This pump is manufactured by the The Deming Co., Salem, Ohio.

Figure 23 illustrates the "Gem" Brass Spray Pump, attached to a barrel cart. This pump may be attached to any barrel by a clamp, as shown in the figure. It is also manufactured by the Deming Co., Salem, Ohio. By the use of this pump, with a kerosene barrel, placed on a wagon, a very serviceable and cheap spraying machine is secured.

ACKNOWLEDGMENTS.

I am under obligations to Prof. H. Osborn for the determination of Thrips tritici, and to Dr. P. R. Uhler for the identification of Pamera vincta. Drawings for figures 1, 7, 8, 9, 10, 11 and 12, were made by Mr. J. P. Davies, under the author's direction. Prof. P. H. Rolfs has kindly looked over my manuscript.

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UNIV. OF MICH.
JAN 18 1909

Bulletin No. 48. September, 1897.

FLORIDA
AGRICULTURAL EXPERIMENT
STATION.

A CHEMICAL STUDY OF SOME TYPICAL SOILS
OF THE
FLORIDA PENINSULA.

By A. A. PERSONS.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Florida.

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1897

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SUMMARY.

1. A chemical analysis can indicate with accuracy the total amounts of the different soil constituents occurring in a soil, but cannot state exactly what proportion of any constituent is in an available condition.

2. The soils of the central and southern portions of the Florida Peninsula are popularly included in four divisions: Pine Land, Hammock, Sand, and Muck Soils.

3. The Pine, Hammock, and Sand lands are essentially of a sandy character, the average of thirty-six analyses from various and widely separated localities in the peninsula showing them to be composed of slightly more than ninety-six per cent. of insoluble residue (sand and insoluble silicates).

4. Chemical analyses show them to be most deficient in potash and least in phosphoric acid. The average amounts of the three so-called essential elements are as follows: Nitrogen, .0409 per cent.; potash, .0094 per cent., and phosphoric acid, .0687 per cent. In addition, it is shown that, in numerous instances, these soils are deficient in humus as well as in lime.

5. When soils are in a fertile state, the most effective method for maintaining their fertility involves intelligent fertilization, a judicious system of crop rotation, and proper cultivation.

6. The most reliable method for ascertaining the deficiency of any element in a soil is by conducting upon it practical fertilizer tests according to the directions described herein. Where practicable, and when it can be intelligently accomplished, farmers should purchase only the raw fertilizing material and do their own mixing. By exercising reasonable economy and prudent methods, several dollars can be saved in this way on each ton of fertilizer mixed. Explicit directions for mixing fertilizers are given in this bulletin.

7. Where soils are deficient in humus and nitrogen, these materials can usually be most economically provided by growing upon such soils certain leguminous crops, (i. e., cow-peas, Florida clover, or beggar weed, and the velvet bean), which have the power of appropriating atmospheric nitrogen.

8. The muck soils of the peninsula are uniformly of a fertile character. The purest muck beds, occupying vast areas in the central and southern peninsula, extending from Osceola County southward into the Everglades, are unusually rich in nitrogen, but, in most cases, are deficient in potash, phosphoric acid and lime. Vast tracts of this land in Osceola and Dade counties have already been drained by cutting canals through the muck beds and are now in a high state of productiveness. Other rich muck areas lie along either bank of the Kissimmee River, which connects Lake Okeechobee with Lake Kissimmee. In order to drain these lands artificial drainage will have to be resorted to, since, even at low water, the river is almost on a level with the contiguous muck areas. In this case the water can be most effectively drained by constructing levees and employing pumps. Still other vast muck deposits occur south of Lake Okeechobee and extend into the Everglades. In addition to the above, muck deposits of varying areas occur all over Florida.

9. As a rule, the purest muck deposits contain the smallest stores of mineral plant food, but are richest in nitrogen. Many samples are reported in this bulletin, however, which are very pure mucks and which, in addition to nitrogen, contain noticeably large supplies of both phosphoric acid and lime. Only in potash do they appear to be very deficient.

10. The average amounts of the several so-called essential plant foods occurring in all muck analyses reported herein are as follows: Nitrogen, 1.9411 per cent.; potash, .0443 per cent.; phosphoric acid, .0897 per cent.

11. In some instances, the muck soils contain excessive amounts of chlorin in the form of common salt. In all such instances this chlorin is highly injurious to growing vegetation and should, therefore, be removed. Usually its removal can best be accomplished by thorough drainage according to some of the methods herein given.

12. Even after this defect has been remedied, it will frequently occur that muck soils will not be at once productive on account of not being in proper tilth. Effective methods for overcoming this difficulty are thorough plowing and subsoiling, followed by a growth of some forage crop with deeply penetrating roots. It will also be found necessary in

many instances to administer applications of lime to correct acidity and improve the mechanical condition of the material. With these precautions observed, muck soils should soon be brought into a condition for profitable cultivation.

13. MUCH IS CONTAINED IN THIS BULLETIN THAT PROPERLY WOULD NOT COME WITHIN THE PURVIEW OF A TECHNICAL PUBLICATION. IT WAS DEEMED DESIRABLE TO INCLUDE SUCH INFORMATION IN ORDER TO MAKE THE BULLETIN AS USEFUL AS POSSIBLE TO THE AGRICULTURAL CLASSES AND TO PROSPECTIVE SETTLERS.

INTRODUCTION.

Probably no other question has afforded a subject for so much discussion among farmers, and in the public press of Florida, as that of the composition of the soils of the State and their capacity for producing successful yields. The frequent inquiries that have come to this department from time to time since the establishment of the Experiment Station, have long ago made it apparent that both a chemical and a physical study of the soils of this State would be highly desirable to those engaged in agricultural pursuits. The Station authorities have always realized the necessity of undertaking these especial lines of work, and, so long ago as 1888, my predecessor here, Dr. Pickell, planned to carry out a line of chemical investigations, but, owing to the limited chemical force at his disposal for carrying on the necessary work, he was forced to abandon such investigation for the time, in order to take up other lines of analytical work which seemed more urgent. Since assuming charge of this department in September, 1892, although the necessity for such a soil study has been constantly apparent, the writer, too, has found it impossible to publish anything along this special line until the present time. In the near future it is earnestly hoped that it will be found practicable to undertake a physical study of the soils of the State, along with the chemical, for such a study is now recognized to be, at least, of equal importance with the latter, in arriving at a correct understanding of the needs and requirements of soils. It is to be noted that data, concerning the chemical composition of the different types of Florida soil, up to this time, has been very meagre. Just prior to, and during the World's Fair, Professor Norman Robinson, at that time the State Chemist of Florida, made a few analyses of some typical Florida soils to be used in connection with the Florida exhibit on that occasion. The Department of Agriculture at Washington has also given some attention, both chemical and physical, to certain types of Florida soils, particularly muck, and the results of these investigations have already been of much importance to practical agriculture. But, aside from these instances, nothing of consequence, so far as the writer is aware, has ever been done along this special line. The demand for such information as the chemical analysis of a soil will afford, has been so urgent during the past year as to render it imperative that such work be carried out in this laboratory, and the present bulletin, including practically a complete preliminary study of the typical soils of the counties of the Southern and Central Florida peninsula is indicative of the progress that has thus far been made.

It is to be regretted that it has not been practicable to include the soils of the entire State in this bulletin, but, owing to the lack of available force for carrying on the necessary work, it has been impossible to accomplish more at the present time than is published herein. It is our purpose to continue this work without intermission, until our researches include all of the different types of soil to be found in the State. It is hoped that a subsequent bulletin, including the remainder of the counties, will be issued from this laboratory about a year hence.

It is but proper acknowledgment to state that all the analyses reported herein, except when otherwise mentioned, were ably performed by Mr. J. P. Davies, the assistant chemist of the Station, and the methods pursued by him in carrying out all analytical work, were essentially those adopted by the Association of Official Agricultural Chemists at their session in 1895.

How the Soils Were Collected for Analysis.

Before considering individually the analyses reported herein, it would seem desirable that mention be made of the plan that was pursued in collecting the soil samples which are included in this bulletin. In order to make the work as uniform and accurate as possible, the following course was pursued in collecting all samples for analysis: Several collectors were appointed in each county (where practicable) and accurate instructions were issued to each collector, fully setting forth the plan to be followed in collecting samples and requesting such information as to the normal vegetation, i. e., trees, herbs, grass, etc., growing upon each soil, as might be of assistance in studying soil-characteristics and interpreting analyses. In addition, all possible information that would serve to throw light upon the physical characteristics of each soil was invariably solicited. The method for taking the sample from the field was that recommended by the Association of Official Agricultural Chemists.

It was our belief that, in thus studying the typical soils of each county separately, no opportunity would be afforded for the omission of any prominent soil, and our investigation, therefore, would be sure to include every soil that could possibly be of any importance to agriculture. It is to be regretted that it was found impossible to procure samples from every county, and the desired number from several counties included in this bulletin, still it is believed that the analyses that are published are fairly representative of the typical soils of the Central and Southern peninsula. As soon as possible, after being received, each sample, after proper preliminary treatment, was bottled, labeled and carefully placed aside for analysis and, in due time, was taken in its regular turn to be analyzed by the chemist.

The Development of Scientific Agriculture.

Agriculture, though one of the oldest of pursuits, as a science, it is of comparatively recent origin. This results from the fact that it is dependent on so many other sciences which are themselves of such recent origin. These latter sciences had first to be developed before agricultural science could rest upon a permanent basis. The sciences of chemistry, of biology, of mechanics, of geology, of meteorology and of botany, had first to be worked out. For chemistry teaches the farmer the composition of his soil and of the plants growing upon it; of the atmosphere surrounding him and the water he drinks, and employs otherwise for various purposes in his profession. Biology acquaints him, not only with the selection and care of the live-stock at his command, but also with the insect friends and enemies that he will be called upon either to foster or combat. Mechanics informs him regarding the proper construction of his farm houses, farm implements, etc. Geology tells him of the original structure of the rocks out of which his soils were made and this knowledge is often of much value to him in his practical farming operations. Meteorology instructs him in studying the seasons, etc., and the benefits to be gained from a proper observance of the same. Botany acquaints him with the laws that govern the selection, propagation, habits and care of the several forms of vegetation that he is called upon to grow.

It is not claimed that the farmer must have an accurate knowledge of each of these sciences in order to practice his profession to the best advantage, but he must be, at least, somewhat acquainted with each. Every successful farmer is, to some extent, a scientific man and every farmer, whether he is conscious of it, or not, if he is a successful one, is practicing, in some measure, the principles underlying the sciences which have been cited.

As recently as 1830, it was an unsolved problem as to whether mineral matter was necessary to the life of a growing plant. Since that time, there have been many theories and conflicting ideas concerning the relation between the plant and the soil in which it grows and the theories applicable to the discussion have been modified and governed by the times in which they were promulgated. Indeed, it is true that only about thirty-five years have elapsed since agriculture came to rest on a truly scientific basis, for it was about that time that Liebig first discovered the true philosophy of plant nutrition. His discovery was not made until a bitter experience had told him that theories, however plausible, were often disproven by practical tests. Before this great investigator discovered the true philosophy of plant nutrition, he examined plants from every portion of the world. He found that all plants contained the same ash constituents, although they occurred in varying proportions in different plants. From this fact, he concluded that all plants took from the soil certain mineral substances and that, unless these substances were returned to the soil, the time would inevitably come when the fertility of the soil from which they were removed would be seriously impaired. It was upon this theory that the manufacture of artificial fertilizers was founded. At first, the employment of these fertilizers was not satisfactory because, as was afterward learned, they were then prepared in the most insoluble form possible and necessarily, therefore, when applied to soils, they could not yield beneficial results. It was not until later investigators discovered that plant-food must be in a soluble form before it can be appropriated by growing crops, that methods were devised for effecting this change, and then the manufacture of artificial or commercial fertilizers became a pronounced success. After it was known that the ashes of plants and soils were alike in their composition, it was at once assumed that a close relation existed between them and that a chemical analysis would reveal that relation. It was naturally inferred that where a particular soil failed to produce a profitable crop, a chemical analysis of its ash would show what the plant lacked. But when the operation was carried out, it was soon discovered that a soil analysis frequently would fail to show a deficiency in any plant-food essential and still a crop would fail to grow upon it. Hence, for a chemist to have stated that a given soil was necessarily productive because he had found present in it all of the elements that plants required in growth, would have been a great mistake, for a practical test would often have proven his statement false. This is probably the chief reason why so many are today skeptical concerning the ability of the chemist to render much practical assistance to the agriculturist in studying the needs of his soil.

The Value of a Chemical Analysis.

There is brobably no one subject in connection with their profession, that is so little understood by farmers generally, as that of the real value to be attached to a chemical analysis of a soil. Indeed, I may say, that there is scarcely a question that is the subject of so much discussion and disagreement, even among the agricultural chemists of the country, as that of the real importance to be attached to such an analysis.

One line of authorities, headed by Dr. Hilgard, the Director of the California Experiment Station, relies most strongly upon such an analysis, while others, of perhaps equal prominence, at least in other lines, do not place so much reliance upon it. All agree, however, that something is to be gained by a careful chemical study of a soil. Even those who do not agree wholly with Hilgard, concede that, whilst a chemical analysis fails to indicate the exact degree of availability of soil constituents, it will at least reveal the approximate total quantity of the several constituents present therein, and in thus indicating either the sufficiency or deficiency of the several soil essentials, it proves itself very helpful to the agriculturist, even though it does fail to show the exact degree of availability of a single soil constituent. It must be conceded that, if it does this only, a chemical analysis is of sufficient importance to warrant its being undertaken, for, if it can tell a farmer that his soil contains a sufficient quantity of one element, and is probably entirely lacking in another, it at least affords him a rational basis for inaugurating a series of practical soil-test experiments with fertilizers that will enable him to answer the question definitely and thus save himself the risk of purchasing and applying certain fertilizers on a particular soil that are not needed by it and that would prove a useless expenditure if applied.

It will be seen that the weak point in an analysis is that, while it reveals what a soil actually contains and in what proportions the several constituents are present, it does not state with absolute accuracy just how much of that plant-food is in an available form, i. e., in a form suited for plant assimilation. This is an important matter, for, other things being equal, the actual productiveness of any soil will depend, not so much upon the total amount of plant-food it contains, as upon the proportion of that food which is in an available form. And, until it is possible for an analysis to reveal, with much accuracy, the degree of availibility of any plant-food essential, it cannot be said that chemical methods are entirely perfected and capable of furnishing information in all respects satisfactory. It is encouraging to note that many chemists are, at the present time, engaged in perfecting methods with this object in view, and the encouragement that they are meeting with is all that could be desired. There is strong reason for hoping that, in the very near future, methods will be devised that will place a chemical soil analysis beyond the point where its practical utility can be questioned, even by the most prejudiced. It frequently happens that when soils are barren their failure to produce is due to the presence of certain poisonous substances, such as sulphate or sulphid of iron. When such is the case, a chemical analysis will reveal the fact and chemistry will provide a remedy.

Sometimes a soil contains an excessive amount of certain soluble salts, such as sodium chlorid (common salt), and where they occur in excessive amounts it is known that they seriously interfere with its productive capacity. A chemical analysis will readily detect this defect and it can be quickly remedied by drainage and irrigation. And if a soil is deficient in any important element of plant-food, a chemical analysis, as has been said, will reveal the fact, and chemistry will prescribe the form of fertilizer to be applied in supplying the deficiency.

All of this information is directly in line with that the prospective settler and intelligent farmer invariably desires, and it helps to answer such queries as the following that are constantly coming to this laboratory:

(1) Is this soil sample capable of producing a good crop without fertilizer?

(2) How long can I continue to cultivate it without fertilizing it?

(3) In what element does it appear to be most deficient and what kind of fertilizer is it likely to require first?

(4) To what kind of crops does it seem best adapted?

While a chemical analysis cannot definitely answer everything in connection with the above queries, still it can aid very much in solving all such problems, and, together with a physical analysis, can contribute much valuable information along all such lines.

Origin of Soils.

The term "soil" is used to designate that mixture of mineral matter and decayed vegetable matter that is found on the surface of the earth, and in which plants grow, and from which they derive a large portion of their food. Soils, therefore, consist chiefly of mineral substances, together with organic remains, and they also contain certain living organisms whose activity may either favorably influence, or else retard, vegetable growth. In addition to this, soils also hold varying quantities of gaseous matter and water, both of which are highly important factors in influencing the proper performance of their several functions. From an agricultural standpoint, the soil proper is the older, and more thoroughly disintegrated, exterior layer of the earth. It is that portion that has longest been exposed to weathering and the influences of organic life. It is usually from six to twelve inches deep, but occasionally extends to a depth of several feet.

The sub-soil is found immediately underneath the soil. As a rule, it is not so thoroughly disintegrated as the soil, due to the fact that it is protected, in a measure, from the several disintegrating agencies by the overlying soil. The sub-soil is usually less fertile, and contains less organic matter than the soil proper. Air circulates more freely in the soil than in the sub-soil, and the metallic elements (such as iron) often exist in the former as higher oxids. It is generally possible to observe a difference in color between the soil and the sub-soil, and frequently there appears a very sharp color-line separating them—the soil being usually darker.

While the sub-soil is an important factor in the economy of plant growth, it is the surface soil which concerns us most. Since, as has been stated, soil results from disintegrated rock masses, its character and composition, if formed *in situ*, should generally be the same as the general mass of earth underlying it—except that this debris has been subjected to the solvent action of water and, perhaps, of certain chemicals, as well as the influence of vegetable growth, and these agencies, naturally, have served to modify, somewhat, the chemical properties of the soil thus acted upon. When a soil is heated to low redness it is found that a portion of it volatilizes and a portion of it remains behind in the form of ash. That portion which disappears as a result of heating is commonly designated the "organic" portion, and that which remains behind, the "inorganic" portion of the soil.

Composition of Soils.

The organic portion of a soil is very complex and consists of products of decomposition—products varying between woody-fibre and the gases into which vegetable matter is ultimately converted when completely decomposed.

This organic matter is composed almost wholly of the four elements, carbon, hydrogen, oxygen and nitrogen, in varying proportions. All fertile soils must have present more or less of this organic substance. While all fertile soils must contain this material, it is not essential to fertility that any definite portion of it should be present. In soils known to be fertile, it is found to vary in quantity, all the way from one-half per cent, in the case of thin, sandy soils, to as high as seventy per cent in peaty, or muck soils.

A portion of the organic matter present in soils exists in a form called "humus," which is a mixture of several of the intermediate stages of decay. In a large majority of instances it is to the presence of this humus that the dark color of the soil is due. It is an exceedingly important constituent of soils because it furnishes, in a large measure, the nitrogen necessary for most growing crops. Formerly it was supposed to be an absolutely necessary factor in the productivity of soils. It is now known that this is not true, still, the value of this substance is recognized at the present time, not only as a source of nitrogen, but because it exercises a powerful solvent influence on the inactive phosphoric acid, potash and silica in the soil, and also on account of the excellent influence it exerts on its physical properties. Much more will be said in the course of this bulletin in regard to this substance.

Inorganic Soil Constituents.

The inorganic (mineral) portion of the soil consists principally of the following metals:

Potassium, Sodium, Calcium, Magnesium, Iron and Aluminum, and the following non-metals: Silicon, Chlorin, Sulphur and Phosphorus. All of these substances remain in the ash when either a soil or plant is burned. The mineral portion constitutes the greater part of the bulk and weight of all ordinary soils. In the case of muck or peaty soils, the organic portion frequently predominates.

The mineral portion of any soil is of a complex character, but a knowledge of the intricate chemical composition of the several components would be of little value to the practical agriculturist, and a discussion of this point is unnecessary at this time. A brief description of the several elements that enter into the compositions of all soils will now be given in order to familiarize farmers with the several terms that will be employed in reporting soil analyses that are to follow.

It has been mentioned that the organic portion of soils and plants consists of carbon, hydrogen, oxygen and nitrogen, and a description of these will now be in order:

Description of the Organic Soil Elements.

Carbon is an elementary substance and it occurs in crystalline form in Nature, both as diamond and graphite, and also in amorphous form as coal. Carbon is a large constituent of peats and mucks. It is contained in the organic matter of all soils. The relation of the carbon to the nitrogen of the soil often throws important light upon the character of nitrogenous matter. In combination with oxygen, carbon constitutes the chief food of growing plants. In the form of carbon dioxid (CO_2) carbon is taken in through the minute breathing pores (stomata)| on the under-surface of the leaves of plants in the presence of sunlight. In due time the carbon is assimilated in the growth of the plant, whilst the oxygen is liberated and escapes into the air. In the atmosphere, carbon exists in the form of carbon dioxid gas, in the proportion of three to five parts, per thousand parts of air, by volume. In the form of carbonates, this element enters into the composition of many of the most important deposits occurring in the earth, such as marble, dolomite and limestone, and, in organic form, it also occurs in the shells of the crustaceans. The calcareous (limy) matter of the soil of which carbon is a chief component, is often of the highest importance from an agricultural standpoint. These carbonates not only facilitate the conversion of nitrogenous bodies into forms suitable for plant-food, but they also exercise much influence on the physical characteristics of the soil, in this way influencing its capacity for holding water and permitting its flow through the soil, etc.

Hydrogen is a colorless, odorless and tasteless gas. It is the lightest substance known. It readily burns in the air, forming water, but it will not support combustion. It occurs in a free state in very limited quantities. Small quantities of it are found in certain volcanic gases and in so-called "natural gas," but most commonly it exists in combination with oxygen as water (H_2O) of which it constitutes more than eleven per cent. by weight. Hydrogen also occurs in combination with carbon in a series of volatile substances known as hydrocarbons, and including such products as petroleum, gasoline, kerosene, naphtha, etc. From an agricultural standpoint, in its free or elementary state, hydrogen is of no importance, but when it is combined with oxygen to form water, it is one of the most important of all plant-foods.

Oxygen is a colorless, odorless gas, without taste, and it exists in abundant quantities in a free state in the atmosphere of which it constitutes one-fifth of its volume. In combination with other elements, it forms nearly one-half of the weight of the solid crust of the earth, and eight-ninths by weight of all water is oxygen. There is only one element with which it refuses to combine, viz.: fluorin. In such combinations it forms what are known as "oxids," and with some of the elements, it unites in several proportions forming oxids containing varying proportions of the element. When combined with silicon, phosphorus, carbon, sulphur, etc., oxygen is an essential component of the silicates, phosphates, carbonates and sulphates that occur more or less extensively in the earth. In these forms it is very stable and is rarely set free. Barring several instances (notably the oxids of silicon and iron) these oxids seldom occur uncombined with other elments where they exist as constituents of rocks and soils. The oxids of iron occur very frequently as such in rocks and soils and they play a very important part in organic life. These oxids frequently determine the color of soils, for, as the iron in the soil is converted from higher to lower oxids by being exposed to more or less air, the color of its oxid changes and this change causes the soil to present a different appearance. The iron oxids are also known to play an important part in influencing the absorptive capacities of soils for moisture, and they likewise affect their physical condition and, in addition, they materially influence the oxidation of organic matter in the soil. Experiments have shown that in many substances, including the roots of growing plants, when a free excess of air is prevented, they can readily obtain such oxygen as may be needed, from the iron oxid of the soil, the latter, in turn, being reduced to a lower oxid. The lower oxid of iron thus formed, in turn, soon acquires additional oxygen, again resolving itself into the higher sesquioxid (Fe_2O_3). Under proper conditions this change can go on indefinitely.

Nitrogen is a colorless gas without taste or smell. It exists in a free state in great quantities in the atmosphere. Four-fifths of the volume of the air is nitrogen. Although it occurs in such great abundance in an uncombined state in the atmosphere, there is only one family of plants (viz.: the leguminosiæ) that is capable of utilizing any of it. To this fact is due the great prominence this family of plants has achieved in recent years as soil enrichers. There is no method so effective and so economical for restoring soils that are unproductive as planting upon them some member of this family of plants and, through this agency, remove from the air and restore to the soil for the use of future crops, the costly element nitrogen (in the absence of which, it is impossible for any form of vegetation to survive) and, at the same time, increase its supply of humus by plowing under vines, stubble, etc., to undergo decay. Combined with hydrogen, nitrogen forms ammonia (NH_3) This is the form in which nitrogen is usually reported in fertilizer analyses. Fourteen pounds of nitrogen, combine with three pounds of hydrogen to form seventeen pounds of ammonia. Probably in this fact is found the reason why fertilizer manufacturers habitually report the amount of nitrogen occurring in a sample as "ammonia." Larger figures are used to express the nitrogen equivalent in the form of the latter gas, and the farmer, not being familiar with the distinction between the two, when he is called upon to choose between two brands of fertilizer, in one of which the nitrogen is reported as such, and in the other as "ammonia," he is naturally inclined to purchase the one in which larger figures are employed in stating the quantity present. Two brands of fertilizer might contain exactly the same amounts of nitrogen, and if in one sample the nitrogen were reported as such and, in the other as ammonia, to one not familiar with the relation between the two, other things being equal, the latter would appear to be the better fertilizer. As a mineral constituent of soils, nitrogen is found chiefly in the form of nitrates, but, owing to the fact that nitrates are exceedingly soluble in water, it is impossible for them to accumulate in soils that are exposed to heavy rains. Free, atmospheric nitrogen exists naturally in the pores of the soil, and when so situated, it is of some agricultural importance since it is in the soil that the anaerobic organisms are accummulating on the rootlets of some plants where they, doubtless, are engaged in a process of fixation of the nitrogen of the atmosphere and putting it in assimilable form. It is not believed that nitrogen, in a free state, can be absorbed by the tissues of plants. It must be first oxidized into nitric acid before it is capable of being utilized.

Sea-Weed as a Source of Nitrogen.

It is now known that some varieties of sea-weed, in a green state, are valuable sources of nitrogen. Jenkins has shown, from the analysis of several varieties, that they are fully equal in fertilizing value to stall manure and still they are sold at a rate of five cents per bushel. This investigator has been fully corroborated in his statements by other eminent scientists, such as Goessman, Hartwell and Wheeler. All are aware that sea-weed has long been esteemed as a fertilizer. As early as the fourth century, its value was clearly recognized and it has come to be more and more appreciated in later days, since a chemical investigation has corroborated the views held in those early times, that it possessed great value for fertilizing purposes. To illustrate the commercial importance of this material, it is only necessary to state that in 1885 its value as a fertilizer in the State of Rhode Island, alone, was $65,044, while the value for all other fertilizers for the same year was only $164,133. In Florida sea-weed ought to be an article of great agricultural importance since it occurs in great abundance in various sections of the State and adjacent to lands that would be highly benefited by its application. When applied to soils in warm climates like that of Florida it, doubtless, would be safer to allow the weeds, after cutting, to die and enter upon decay before applying them to the soil, in order to avoid the risk of souring the latter by applying them in the green state and allowing them to undergo rapid decomposition.

The elements that we have thus far described constitute what are usually called the "organic" elements of the soil. It now remains to describe those elements that compose the mineral portion of the soil, and which are left behind in the form of ash when the soil is burned.

The Inorganic Soil Elements.

These are Potassium, Sodium, Calcium, Magnesium, Iron, Aluminum, Silicon, Sulphur and Phosphorus. In addition to the foregoing, Manganese and Barium (metals) and Fluorin and Boron (non metals) are frequently found in small quantities in soils, but, for general agricultural purposes, they are of such inferior importance as to render only mention of them necessary. To the farmer, the two most important of this latter division are Potassium and Phosphorus, since these are the only ones that are likely to be deficient in a soil, but a brief description of all the principal ones will now be given.

Potassium is never found in a free state in Nature. Combined with silica, it is an important component of many mineral silicates such, for example, as orthoclase. Granite rock also contains considerable quantities of potassium in complex forms, and when these rocks disintegrate, their potassium slowly becomes available as plant-food. Potassium also occurs in small quantities as chlorid in sea-water, and it is found in great abundance in certain rainless, tropical countries naturally formed in the soil, and in this form is known as potassium-nitrate, or "saltpeter." To the farmer, this element is of great importance, since it is one of the three that are usually deficient in soils and which must be applied in the form of fertilizer before a soil deficient in either can become productive. An important home source of potassium is hard-wood ashes. Ashes that result from the burning of hard woods, such as oak, hickory, etc., consist largely of potassium in the form of carbonate. Ashes are simply the mineral substances that are removed from the soil by plants during growth. Potassium is universally distributed in soils, and many virgin soils are apt to contain enough of this element in an available form to last for some years in a system of cropping, before it becomes necessary to replenish its supply in the form of a fertilizer application. In the form of kainite, etc., large quantities of potassium are used, not only for fertilizing, but also for the manufacture of pure salts for pharmaceutical and other purposes. The ordinary salts of potassium are very soluble, and hence cannot accumulate in large quantities in soils exposed to heavy rains. The most extensive potash deposits in the world occur in the vicinity of Stassfurt, in Germany. It would be interesting briefly to refer to the theory of the formation of these deposits, but this can hardly be done at the present time. Suffice it to say that these vast salt mines are, at present, the chief source of the potash that is used in manufacturing commercial fertilizers throughout the entire civilized world.

Sodium is never found free in Nature, but occurs most commonly combined with chlorin to form sodium chlorid ($NaCl$). Combined with silica, it is an important element in many silicates. Although this element is closely related chemically to potassium, it cannot, in any case, be substituted for it in plant nutrition. It closely resembles potassium, both in its chemical and physical properties. In combination with nitrogen, it forms sodium-nitrate commonly called "Chile-saltpeter." This latter name is derived from the fact that it occurs as an incrustation on the surface of the soil in Chili. On account of its content of nitrogen, Chile-saltpeter is a valuble fertilizer, and large quantities of it are shipped annually into this country, and into other countries, as a commercial source of nitrogen in manufactured fertilizers. Sodium is of little agricultural importance, as yet, because soils at present are not likely to be deficient in it, as is the case with their stores of potassium, phosphorus and nitrogen, and the farmer, therefore, never finds it necessary to purchase it for fertilizing purposes. Nitrate of soda is employed, not because it contains sodium, but on account of its nitrogen. A good quality of nitrate of soda contains about sixteen per cent. of nitrogen.

Calcium occurs very abundantly as one of the constituents of the earth's crust, of which it is supposed to compose about one-sixteenth. It does not occur free in Nature and it is a metal exceedingly difficult to separate from its compounds. Its most common form of combination is with carbon dioxide, forming the minerals marble, calcite, and the very abundant lime-stone rocks. All of these substances are chiefly combinations of calcium with carbon dioxide. As it exists in limestone rock, calcium is slightly soluble in water containing carbon dioxide, and hence, it has become a universal component of soils and is also of general occurence in natural waters. In such waters, it is the chief ingredient that is employed in the formation of the shells and skeletons of the several tribes of mollusca and corals. Calcium also exists in combination with sulphuric acid in Nature, and when occurring thus, it forms the well-known substance, gypsum. Lime is a combination of calcium and oxygen (CaO) and is formed by burning lime-stone or calcium carbonate. Calcium is sometimes applied to soils in the form of lime, but, more frequently, the lime is slaked with water before applying it, in order to modify, somewhat, its active caustic effects. Calcium is not only an essential plant-food but it influences, in a marked degree, both the progress of nitrification in the soil and its physical condition. Frequently, stiff, clay soils, which on account of their toughness and compactness do not admit of cultivation, are rendered porous and pulverulent by the application of lime and are thus brought into a suitable state for cultivation and become quite productive. Not only is it an essential ingredient of soils and plant-food, but it is the chief component of the bones of all animals. Referring to the presence of lime in soils, Professor Hilgard says: "Other things being equal, the thriftiness of the soil is immeasurably dependent on a certain minimum percentage of lime." Where lime occurs in proper proportion in a soil, Professor Fulmer (Bulletin 13 Washington Experiment Station) thus summarizes the beneficial effects resulting from its presence:

(1) A more rapid transformation of vegetable matter into humus.

(2) The retention of humus against the oxidizing effects of hot climates.

(3) Whether through the medium of this humus, or in a more direct manner, it renders adequate for profitable culture percentages of phosphoric acid and potash so small that, in case of a deficiency of lime, or its absence, the soil would be directly sterile.

(4) It tends to secure the proper maintenance of the conditions of nitrification, whereby the inert nitrogen of the soil is rendered available.

These, in connection with other physical influences it is known to exert, make lime an exceedingly important constituent of soils and one, which, on account of its cheapness, can be very easily supplied. It is one of the most available soil constituents, existing in some soils in mere traces, while in others it occurs in proportions approximating 30 per cent. of the total weight of the soil. Combined with phosphoric acid, it constitutes the well-known phosphate deposits that occur extensively in Florida and other sections of the country. When present in soils in relatively small proportions, it has been found that they will respond more readily to applications of potash fertilizers, but this does not mean that it should not occur in all soils in sufficient quantities to supply all agricultural demands.

Magnesium is found in Nature chiefly in combination with carbon dioxid, or with lime and carbon dioxid, in the mineral, dolomite. Its oxid (MgO) resembles lime in many of its properties and it is generally found associated with it in rocks. It is found in all cultivated soils and seems to be essential to the perfect development of many plants. Evidence is constantly accumulating to prove that its presence in the soil is necessary for the full development of many cereals, such as wheat, barley, etc. Magnesium is an essential constituent of such rocks as talc, serpentine and soap-stone. This element is not so important a factor in agriculture as are those we have already described, and as are others to be described hereafter. Still, as has been stated, it seems to be indispensable to certain varieties of vegetation. Although it is an important ingredient of certain forms of plant ash, yet it is well known that soils resulting from the disintegration of magnesium lime-stone are inferior to those that are derived from pure lime-stone. There are a great many scientists who do not regard magesium as of very great consequence, either as a plant-food or as a fertilizing material.

If the lime is applied as gypsum, in addition to other beneficial effects, it is unusually effective in relieving the inert potash of the soil.

Iron is the most abundant, and, in the arts, the most useful of the heavy metals, and it occurs in Nature usually combined with other elements. Small quantities of it exist in a free state in basaltic rocks and meteorites. In combination with oxygen it is one of the most widely diffused elements and a large number of rocks and minerals owe their coloring matter to the presence of this metal. In the form of oxids, iron also exists in the valuable ores commonly called "hematite" and "magnetite." In combination with sulphur it forms the mineral "sulphur pyrites," (FeS_2), commonly called "Fool's Gold." Nearly all red or yellow soils owe their color to the presence of iron oxids. In addition to its wide and varied uses in the arts, iron is also an important plant-food, although it is not taken up in very large quantities by the tissues of plants. It occurs in different soils, varying in quantity, usually from one to twenty per cent. Although the red color of soils is usually due to the presence of iron, still it frequently happens that soils distinctly red contain less iron than others of a much darker color. The color apparently is due to the mode of distribution of the iron, rather than to the quantity of it present. Usually it is the case that the more iron a soil contains, the less will be the quantity of organic matter present, but this does not mean that the supply of organic matter will be sufficiently small to render a soil unproductive. It is believed that the influence iron exerts on the productivity of soils is chiefly mechanical in that it is believed to be capable of increasing the power of the soil to absorb and retain heat and moisture, and, in the case of clay lands, of rendering tillage easier. Iron is also known to improve the green color of plants and it probably exerts other beneficial chemical effects. But these latter are, at present, not well understood.

Aluminum, next to oxygen, is probably the most abundant element of the earth's crust, of which it is believed to form about one-twelfth. Aluminum does not exist in Nature in a free state. Its most common form of occurrence is in combination with silicon and oxygen, and when so combined, it is an important constituent of kaolin, slate, clay, feldspar and mica, and it also enters into the combination of various other rocks and minerals. In the process of "weathering," feldspar, mica and other minerals containing aluminum, in chemical combinations, undergo partial disintegration and kaolin (true clay) is formed as a result. This is of very great importance to the soil. Aluminum is not regarded as of very much importance as a plant-food, still in the form above referred to, it is an exceedingly important constituent of the soil, for its presence, or absence from it, modifies very greatly its physical properties. While this metal is not considered of very great importance as a plant-food, still the fertility of the soil, as has been stated, is very largely dependent on the quantity of clay which it contains, for it is this clay that influences, very largely, its ability to absorb and retain moisture, and that puts it in a desirable condition for cultivation.

Silicon occurs abundantly in Nature in combination with oxygen, and in this form is known as silica (sand). As such, it constitutes a large portion of various rocks and soils. It forms about one-fourth of the solid crust of the earth. Silica is seen in its purest form in quartz crystals. The sand that glass blowers employ is also nearly pure quartz. As has been previously mentioned, silicon is an essential component of many minerals, such as the feldspars, mica, etc. Silica is only very slightly affected by the ordinary forces concerned in the decay of rocks (rain, frost, freezing, etc.,) and even after the crystals of feldspar, mica and other minerals occurring in rocks, have been disintegrated, the silica remains as hard grains of sand, forming the larger portion of most soils. In the form of sand, it is believed to be chemically inert as regards plant growth, but in such form it plays an important part both in the physical structure of soils and in their physical relation to plant growth. Some chemists doubt whether silicon is a necessary constituent of plants, but all agree that it is found in the stems of grass, wheat, corn and various varieties of vegetation. It is probably true that most fertile soils contain some silica in a soluble form and, in this form, it is a source of plant-food.

Sulphur occurs both in a free and combined state in Nature. In a free state, it occurs in volcanic regions such as Sicily, Iceland, and the Western United States. We are quite familiar with this substance in the form of "flowers of sulphur" found in every drug-house, or as "brimstone," which is simply sulphur molded into sticks. Sulphur possesses a well-known yellow color and burns with a pale, blue flame and very suffocating odor. In combination with oxygen and hydrogen, this element forms sulphuric acid, or "oil of vitriol," which is the strongest of the ordinary mineral acids. Sulphuric acid is very extensively used in the manufacture of fertilizers. The usual form of occurrence of sulphur in soils is in combination with metals to form sulphids, or with oxygen and metals to form sulphates. It combines with iron to form iron pyrites (FeS_2), while with oxygen and calcium it constitutes the well-known mineral, gypsum (calcium sulphate), which is an important fertilizing compound. Sulphur is an important nourishing constituent of plants and is found occurring in them both in organic compounds and as sulphuric acid.

Chlorin never occurs free in Nature, except in limited amounts in volcanic emissions. Most commonly it is combined with hydrogen forming hydrochloric acid, and with metals, forming chlorids. Chlorin also occurs in the ash of plants, as well as in the soil. In the form of common salt, it is an abundant constituent of sea-water. It is a poisonous gas, very irritating to the throat and lungs. In the form of sodium chlorid, it exists as extensive beds of rock salt, and as such, is mined for chemical purposes. It occurs in varying proportions in all plants and must be regarded as an essential constituent of them. When applied to a soil, sodium chlorid (common salt) increases its power to attract and retain moisture. It is frequently found occuring in too large proportions in soils to render them adapted to plant growth, but where fresh water irrigation is practicable and drainage can be accomplished, this difficulty can be overcome. Generally, the occurrence of one part of chlorin per thousand of soil is regarded as injurious to growing crops.

Phosphorus never occurs in a free state in Nature, but, in forms of combination, it exists in varying quantities in all soils. It is also a chief component of the minerals, *phosphorite* and *apatite*, forms of phosphate rock occurring widely diffused in Nature. In forms of combination with other elements, phosphorus is one of the most essential constituents of both animal and plant-food. In animals, calcium phosphate forms nearly all of the mineral matter of their bones and in plant-foods it is the chief constituent of the ash of seeds. The deposits of pebble phosphate and of some rock phosphates are supposed to be of organic origin, i. e., derived from the remains of terrestrial, marine, and aerial animals. To the farmer, phosphorus is one of the most important elements, since it is one of three that are most likely to be deficient in soils, and thus have to be replaced by applications of fertilizers. It is the chief component of phosphoric acid, the substance which is more universally deficient in soils than any other plant-food essential and this is why phosphatic manures are of such importance. As has been already stated, rock phosphate occurs in immense quantities in Florida. It is also found in large quantities in South Carolina, Tennessee, and in considerable amounts in North Carolina, Alabama, California, etc. In Florida, the supply is practicably inexhaustible. In view of the fact that the demand for chemical fertilizers is increasing all the while, it is not improbable that the State of Florida will yet become immensely wealthy from the development of this single industry. The quality of the phosphate rock mine in this State is not inferior to that mine elsewhere in the United States, and the scientists of the world now recognize the superority of our deposits and, accordingly, they are used very extensively. As the demand for artificial fertilizers increases, we may expect to see an increased consumption of Florida phosphate until, after a while, the phosphate industry will become to Florida what the iron industry has long been to Alabama. Various explanations by Davidson, Wyatt, and others, have been offered to explain the origin of the phosphate deposits of Florida, but the limit of this bulletin will render it impracticable to attempt a discussion of any of the several theories in this place.

Cereal crops remove about twenty pounds of phosphoric acid, per acre, from the soil annually, and grass crops about twelve pounds. Wiley estimates (Vol. I Agri. Analysis) that the total amount of phosphoric acid removed annually by the cereal and grass crops, in the United States, is nearly four billion pounds. In a chemical analysis, the phosphoric acid present is usually reported under two divisions, viz., "available" and "insoluble" phosphoric acid. The former, in turn, is often reported under two divisions as "water soluble" and "citrate soluble" or "reverted" phosphoric acid. It will be seen therefore, that when all of the soluble phosphoric acid in a fertilizer is reported under the head "available" phosphoric acid, it means that the "water soluble" and "citrate soluble" forms have been combined. Or, in other words, the "available" acid includes both the "water soluble" and "citrate soluble" acid, and represents the entire amount of phosphoric acid that exists in a form which will permit of being readily taken up by growing crops.

When the term "phosphoric acid" is used in connection with the chemical analysis of a fertilizer, it signifies a compound which is really not phosphoric acid but simply one of phosphorus and oxygen (phosphoric anhydrid or phosphorus pentoxid). True phosphoric acid could not well exist as such in a fertilizer. So that in an analysis, the figures under the heading "phosphoric acid" really state the amount of the phosphoric oxide (P_2O_5) above mentioned, which is equivalent to the phosphoric acid, in a form of calcium phosphate actually existing in the fertilizer. True phosphoric acid is a compound of three elements, viz.: phosphorus, hydrogen and oxygen, but in the form in which we are accustomed to use the term, the hydrogen of the acid has been replaced by some other substance, usually lime, (calcium) and a salt is formed, as a result, which is known to the chemist as calcium phosphate.

Enough has been said to render it apparent that "insoluble" phosphoric acid is the form in which phosphorus exists chiefly in most soils. The same is true as regards its mode of occurrence in bones and in the phosphatic rocks which are employed in the manufacture of chemical fertilizers. It is necessary, therefore, for it to be rendered soluble, or available, before it is in proper form to be applied for the purpose of enriching soils.

The way in which crude phosphate rock is usually rendered soluble and readily available, is by treating it with sulphuric acid, thus converting it into what is known as *superphosphate* or *acid phosphate.* This may be accomplished by mixing the ground rock with half its weight of sulphuric acid (previously mixed with two or three times its weight of water). The water should first be placed in the vessel that is to contain the mixtures of acid and water, and the acid should be added very slowly (because a great evolution of heat and steam will be sure to occur) and should be stirred constantly. Next slowly pour the acid upon the ground rock, thoroughly mix, and allow the mixture to stand.

In a couple of hours the reaction will be complete, and then the mixture is left to dry. As a means of getting rid of any excess of acid, which is likely to be present, rich earth, saw-dust or ashes are mixed with the mass and these serve to neutralize the excess of acid. The above treatment converts the insoluble phosphoric acid present in the rock into soluble or available phosphoric acid, and the acid-treated material is now known as acid phosphate, or super-phosphate. It is this form that is generally employed in the manufacture of chemical fertilizers.

Classification of Soils.

Soils have been variously classified by different writers as regards their differing qualities and composition. A very practical and convenient method is the one adopted by Wiley (Vol. 1, page 53, Agricultural Analysis) which is as follows :

(1) *Sand*—Soils consisting almost exclusively of sand.

(2) *Sandy Loams*—Soils containing some humus and clay, but an excess of sand.

(3) *Loams*—Soils inclining neither to sand nor clay, and

containing some considerable portions of vegetable mold, being very pulverulent and easily broken up into loose and porous masses.

(4) *Clays*—Stiff soils in which the silicate of alumina and other fine mineral particles are present in large quantity.

(5) *Marls*—Deposits containing an unusual proportion of carbonate of lime, with often some potash or phosphoric acid resulting from the remains of sea animals and plants.

(6) *Alkaline*—Soils containing carbonate and sulphate of soda, or an excess of those alkaline and other soluble mineral substances.

(7) *Adobe*—A fine grain porous earth of peculiar properties.

(8) *Vegetable*—Soils containing much vegetable debris in an advanced state of decomposition. When such matter predominates, or exists in large proportion in a soil, the term tule, peat or muck is applied to it.

All of these, save Nos. 6 and 7 are well known and occur extensively throughout the United States. In certain arid regions of the West, varieties of No. 6 also occur in great abundance. In the peninsula of Florida the only types that occur in any considerable quantity are included in divisions Nos. 1 and 8. Probably upward of 90 per cent. of the present arable soils of the Florida peninsula are included in the first division.

The Growth of Plants Influenced by the Size of Soil Particles.

As is well known, the size of soil particles has much to do with the growth of vegetation. In a general way, soil particles are ordinarily divided into two classes, designated the soil "skeleton," which includes all coarse particles, such as gravel and coarse sand which are larger than .02 of an inch (.5 millimeter), and "fine earth" which includes all soil particles smaller than .02 of an inch. The former is valueless as a source of plant food and is not included in the chemical study made of a soil. It is the "fine soil" only that is ordinarly subjected to analysis and all analyses included in this bulletin are of those proportions of soils comprised within this division. Only the percentage of total coarse material occurring in each sample is given in the different analyses. In a physical soil study it is customary to divide the "fine soil" portions into sizes included in six divisions, as follows:

Medium sand........	.02 to .01	inches,	.5 to .25	millimeter.
Fine sand.............	.01 to .004	"	.25 to .1	"
Very fine sand.......	.004 to .002	"	.10 to .05	"
Silt.......................	.002 to .0004	"	.05 to .01	"
Fine silt...............	.0004 to .0002	"	.01 to .005	"
Clay less than......	.0002	"	less than .005	"

In order to show the extreme fineness of some of the smaller particles, Snyder (Bulletin 41 Minn. Exp. Sta., page 59) estimates that it would require at least five thousand clay particles, laid side by side, to measure an inch. The very fine sand, silt and clay, are only stones of microscopic size. Much depends upon the form of these different particles. If they are irregular and angular they fit together more closely and make a more compact soil than when they are in the form of small round particles.

Density of Soils.

As is well known the various classes of soils possess different weights, and a soil in good tilth weighs less per cubic foot, than one which has been packed by tramping, such as a road, or a well-pastured field. It would be interesting to discuss here the distinction between the apparent and real specific gravities of soils, but such a discussion would come more properly in a physical study which it is hoped can be undertaken at a later day, and we have not space for it at this time.

Schubler (Stockbridge Rocks and Soils, page 153) estimates the weights per cubic foot of different types of soil to be as follows:

Sand	1.10	pounds.
Sand and clay	96	"
Common arable soil	80 to 90	"
Heavy clay	75	"
Vegetable mold	78	"
Peat	30 to 50	"

It is usually the case that the specific gravity of a soil decreases inversely as its content of humus.

Humus and Its Influence on the Fertility of the Soil.

It is impossible to assign a definite formula to humus. It is a combination of several complicated organic compounds, which are found during processes of decay. It serves our purpose to regard various forms of humus bodies as "mixtures of many substances, mostly of acid nature, undergoing decomposition under conditions which partially exclude free access of oxygen." Besides the four elements, carbon, hydrogen, oxygen and nitrogen, which are the chief components of humus, it also contains certain quantities of sulphur, phosphorus, and iron in organic combination. The amount of this humus present in soils is influenced largely by the character of the vegetation growing upon the latter and the method of cultivation employed. This organic matter (humus) of soils is of great importance and a supply of it must be kept up because it takes such an important part in maintaining fertility. A good way to do this is to practice a good system of crop rotation and employ well prepared farm manures. Where it is convenient to employ such a system, the necessity for purchasing commercial fertilizers will be greatly relieved and, thus, at least a large portion of the $36,000,000 that are now annually expended in this direction by the farmers of the country will be avoided. It sometimes happens that surface soils are rich in phosphates and nitrogen, while sub-soils contain larger proportions of potash and lime than of other constituents. Under such conditions, a good system of crop rotation will be the most effective method for bringing the soil and the sub-soil into a condition of equilibrium by uniformly disseminating the predominating fertilizing ingredients of each, thereby placing the soil in a desirable state for cultivation. Something more concerning crop rotation will be said in a subsequent chapter.

One of the ever present and most substantial components of humus is nitrogen, and the importance of this element, as a plant-food, has been frequently mentioned in these pages. It is an important constituent of all animal fluids and tissues, and, in the vegetable kingdom, it is known to enter into the composition of all plants. It is found in largest proportions in the leaves, flowers and seed of the latter. When all plants are deprived of an adequate supply of nitrogen they exhibit a sickly yellowish appearance and will fail to produce a satisfactory yield of seed. Now, humus is known to be one of the chief sources of supply of nitrogen, (since, as has been stated, this element invariably enters into its composition), and this is one reason why this material is so favorably regarded by the intelligent agriculturist.

A careful observation of the sandy soils of Florida during the last five years, together with a chemical study of them as revealed herein, makes it apparent that, in a large number of instances, they are deficient in humus, and, with a proper supply of this substance, there appears to be no doubt that very often their productive capacity can be largely increased. That they are deficient in humus is revealed not only by the chemical analysis, but by the sickly yellowish (instead of dark green) appearance of green crops growing upon them. Other indications of an insufficient supply are:

(1) The ease with which certain leguminous crops thrive upon them because of their ability, indirectly, to attract nitrogen from the air, whilst other green crops, not being able thus to appropriate nitrogen, and which are, therefore, dependent chiefly on humus for their needed supply of this element, fail to make a satisfactory growth.

(2) The rapidity with which they part with water after rains and irrigation. Sufficient stores of humus would enable them to retain moisture much more effectually, and, as a result, crops growing upon them would be less likely to suffer from drouth.

Our present knowledge of the value of humus as a soil renovator and the experience of numerous scientific investigators, who have devoted much study to the subject, warrant the assertion that thin sandy soils, containing an insufficient supply of decomposing organic matter, can be very greatly improved by supplying to them sufficient quantities of this substance. How best to do this, under different circumstances, is a question that every farmer must settle for himself. One admirable source of supply of this humus to the soil is well-rotted stable manure, but, unfortunately, it is seldom the case that this substance is present in sufficient quantities on a farm to supply all demands. Where it occurs in sufficient quantities to do this, there is no better source, either of humus or phosphoric acid, potash and nitrogen. But because of the insufficiency of it, it nearly always becomes necessary for the farmer to resort to other means for supplying the needed amount of humus, and it is now known that "green manuring" is not only the most economical, but the most effectual method, as well, for accomplishing this result. By "green manuring" is meant planting certain crops upon a soil and subsequently plowing them under for the purpose of improving both its chemical and mechanical condition. Any vegetable growth, even green, or dry stubble, is valuable for this purpose, but accurate experiments have demonstrated that the legumes (beans, peas, clover, vetches, lupines, etc.,) are greatly to be preferred for supplying soils with the needed humus, as well as nitrogen, for it has been already stated that this family of plants have the ability to utilize atmospheric nitrogen during growth and furnish it to the soil when they die and decay. They are enabled thus to employ nitrogen through the agency of certain bacteria that live and die in the nodules that occur on the roots of this family of plants. These bacteria appropriate the free atmospheric nitrogen, and it is eventually transformed into plant-food. Not only do these vegetable fertilizers, and stable manure as well, add new elements of fertility to the soil, but they change a part of the inert phosphates, potash and lime already in the soil, into available forms.

Some of the *leguminosiæ* are better suited to particular soils than others. Some will grow upon soils that others will not thrive upon. Some thrive best under one climatic condition and some another. Here in Florida, the aim of the Station authorities has been to ascertain, by means of practical tests, the particular varieties that succeed best in our sandy soils and peculiar climate. Of course, as is well known, varieties of the common field-pea are usually well adapted to our conditions, but, in many localities, even this plant has not done as well as was hoped for. There are certain sections in which it does not flourish and where other legumes have given better results. Two, at least, are deserving of mention in this connection, and brief reference will now be made to them.

The Beggar Weed (*Desmodium molle*) as a Soil Renovator.

Florida clover, or beggar weed, has proven itself to be admirably adapted to the sandy soils of this State. Not only does it gather nitrogen from the air and enrich the soils with it, but, by means of its long roots, it penetrates soils, to considerable depths, in search of food and brings it nearer the surface, where it is placed in reach of all cultivated crops of ordinary habits or growth. Florida clover grows in various portions of the State and analyses, in this laboratory, have shown it to possess exceedingly high feeding value. It appears to be equal to the best meadow hay in this respect and all stock consume it with great relish. Here, in Florida, it is already highly prized by some for planting upon worn sandy soils, to improve their mechanical condition, and the great merit it possesses for this purpose, and its high feeding value, are sure to bring it, eventually, into more general use. It is a wild, rank grower in many sections, and can be made to flourish without effort, anywhere, and will produce several crops of forage in the course of a single season. It cannot be too highly commended as a renovating agent on the worn sandy soils of this State.

The Velvet Bean (*Dolichos multiflorus.*).

Another legume that has lately come into prominence and that promises to be a valuable agent in reclaiming the worn soils of Florida, and also a most excellent food for stock, is the velvet bean. During the past two years, the Station here has been conducting experiments with this plant and the results have been very promising.

It is now known that the plant will grow luxuriantly all over the State and stock of all kinds are exceedingly fond of it. The practical results in feeding it have been all that could be desired, and the limited study that we have been able to give to it in this laboratory has indicated that it is fully up to the best of the legumes in feeding value.

In the near future, it is proposed to make a complete chemical study of this plant in different stages of growth and publish the information for the benefit of the farmers. There is scarcely a doubt that it will yet play an important part, not only in solving the forage problem in Florida, but in improving both the mechanical condition and productive capacity of our thin, sandy lands, by increasing their stores of both nitrogen and humus and exerting various other beneficial effects.

The limit of this bulletin forbids a more extended discussion of the beneficial effects of humus, but, briefly, the more important are:

(1) It renders sandy soils more compact and retentive of moisture, and clay soils more porous, thus insuring better drainage of the latter, and it also increases the capacity of soils for absorbing the sun's rays.

(2) It prevents over-heating of soils and contributes to a uniformity of temperature during summer and winter.

(3) It enables all soils better to withstand drouth by retaining in them large quantities of moisture. Its action on sandy soils in this respect, appears to be similar to the action of fine clay in stiff soils. In illustration of this, an instance in point is as follows: In bulletin No. 41, of the Minnesota Experiment Station, is given the

result of an experiment to ascertain the value of humus as a retainer of moisture. Two soils (new and old) were selected from near Crookston, in the Red River valley, for conducting the experiment, and the following were the results obtained by Professor Snyder, who had charge of the work:

NEW SOIL.	OLD SOIL.
CULTIVATED TWO YEARS.	CULTIVATED TWENTY-ONE YEARS.
Humus, 3.75 per cent.	Humus, 2.50 per cent.
Water, 16.48 per cent.	Water, 12.14 per cent.

It will be noted that there is a difference of 4.34 per cent. of water in the above example, in favor of the soil with the larger amount of humus, and this is equivalent to three pints of water to a cubic foot of soil, quite a large quantity.

(4) By converting the inert phosphoric acid, potash and lime of the soil into soluble humates, etc., humus renders a large proportion of each of these constituents available, and thus materially increases the quantity of of assimilable plant-food in soils.

(5.) Nitrogen, being a constituent of humus, a large quantity of this element is contributed to soils through its agency.

(6.) Fallowing materially increases the supply of humus, and consequently of available plant-food, in a soil, but at the expense of a considerable loss of the latter. When this method of increasing the store of humus is resorted to, it is usually the case that the inert plant-food of the fallowed land is rendered available more rapidly than it can be appropriated by subsequent crops, and thus a great deal of it leaches out and is wasted. It will depend upon circumstances, and must be settled by every farmer for himself, whether it is desirable to adopt this method for increasing the supply of humus in his soil.

Nitrification and Rotation of Crops.

The term "nitrification" has reference to that process occurring in the soil, whereby its inert or unavailable organic nitrogen is converted into soluble nitrates and ammonia salts. These changes must always occur before soil nitrogen can be assimilated. The conditions which influence favorably this nitrification are as follows:

(1) *Porosity*, which facilitates the circulation of air through the soil, and this, of course, insures the presence, of oxygen, one of the essentials to nitrification.

(2) *Moisture*, but either an excess or great deficiency must be avoided, for both conditions greatly retard the nitrifying process.

(3) *Temperature.* This, too, is a matter of great consequence, The preferable temperature is about 36.6° C or 98° F. The nitrification may proceedin a measure, however, within limits ranging from 4.4° C (40° F) to 54.4° C (130° F).

Under proper management, all soils may be brought into conditions favorable for nitrification. Where the process is interfered with, or the conditions are unfavorable, all farming operations should be conducted with a view to remedying all retarding influences.

Referring to the principles to be observed in practicing crop rotation, Dr. Oemler, in his "Truck Farming at the South," has this to say:

"Neither the areas nor the varieties of crops of the truck farmer are sufficient to enable him always to practice regular courses of rotation; nor should a lack of manure ever compel their strict observance, but he should aim:

"First—To have a crop which succeeds another as dissimilar in composition and the demand it makes upon the soil as possible.

"Second—Never to have plants of the same family succeed each other. For instance, melons should not follow cucumbers, tomatoes should not follow eggplants or Irish potatoes; beans should not succeed peas, or *vice versa*.

"Third—Tuberous plants should not be allowed to follow plants of the same character.

"Fourth—Roots should not succeed root crops, as turnips, beets, etc.

"Fifth—Deep or tap-rooted plants should succeed others of dissimilar growth.

"Sixth—To make the heaviest application of manure to such crops as require most, as cabbage, onions, etc., and have other crops succeed these requiring less, as tomatoes, egg-plant, etc., so that the whole farm may be gradually brought to the same degree of fertility."

Other benefits of rotation are the destruction of noxious weeds and parasitic fungi and insects.

Writing upon the subject of rotation in gardening, Newman (Bulletin No. 44 Ark. Exp. Station) has this to say:

Rotation should be practiced with system in every garden; not alone for the soil's recuperation, but also to lessen the attacks of insects and fungous diseases.

The various vegetables, whether grown for market or home use, occupy the soil different lengths of time, making it possible to produce half a dozen or more crops on the same plot of soil within the space of twelve months. As an illustration of this rapid rotation, the following schedule gives the crops grown at the Southern Branch Station in 1894 on a plot of ground 10x45 feet: (1) Radishes were planted in the early spring in rows 2 feet apart; later, (2) lettuce was transplanted into rows marked off between the radishes; the radishes came off in six weeks, and their rows were prepared and planted in (3) snap beans; every other row of lettuce was planted in (4) corn when the lettuce was cut; the beans were followed by (5) lettuce, and the corn and lettuce by (6) onions and (7) radishes. In 1885 another plot, 15x45 feet, was occupied by (1) onions in January and part of February. The onions were used for bunching, and the plot planted in (2) Irish potatoes on the 25th of February. Early in March, (3) English peas and (4) corn were planted in every alternate potato middle. (5) Beans were planted in corn rows late in April—two hills of beans between each hill of corn. In the latter part of June, the corn and beans were followed by (6) cowpeas, broadcast. (7) Spinach was planted early in October after the peas, and (8) radishes and (9) lettuce alternated in the spinach middles. This rapid change of crops will, to some extent, have a tendency to decrease the attacks of both fungi and insects, if only such plants are used as are not of close Botanic relation. The majority of the plants will have been removed before the insects or fungi attacking them have reached the degree of development necessary for propagation.

When a plant ceases to fruit or there is no further use for it, it should be at once removed, if diseased, and destroyed. The plot should then be manured, prepared and planted again. No garden spot should remain idle. If there is no particular use to which it can be put after the removal of a crop, nothing is better than planting in cowpeas if vacant in spring or summer, and rye or crimson clover in fall. The rye and clover plowed under green will enrich the soil after affording winter protection. No matter in how quick succession one crop follows another, the soil, as a rule, should be manured before each planting, using fermented and well decomposed manures. Fresh or unfermented manures often act disastrously to growing crops. No manure is better than well rotted stable manure, and results from it frequently are better the second than the first year. Its bulk materially affects the physical properties of the soil, and the quality of many vegetables is dependent more upon the physical condition of the soil in which they are grown than upon its fertility.

Some Points on Irrigation and Drainage.

The questions of irrigation and drainage are demanding more and more every year the attention of eastern and southern truckers and fruit growers. Under many circumstances the economy of both can be no longer questioned and the pecuniary benefits to be derived from their practice in all cases where drouths or excess of water are likely is no longer a matter of conjecture. In this connnection, the following comments, taken from Farmers Bulletin No. 56, of the United States Department of Agriculture, upon certain experiments conducted by King, (Wisconsin Station) and Raine, (New Hampshire Station) are very interesting and possess much practical value. Says the aforesaid bulletin:

" King has found that even in favorable seasons in Wisconsin, which is in the so-called humid region, the rainfall does not supply sufficient moisture to produce maximum crops. During the season of 1896, in which the rainfall was normal in that State, a variety of crops was irrigated with profit, notwithstanding the fact that the irrigation plant employed was not used to its full capacity and thus the cost of irrigating was higher than it need be. The profit from irrigation was on corn, $2.16 per acre; potatoes, $11.70; clover hay (irrigating second crop only,) $1.72; cabbages, planted thin, $2.43, planted thick, $29. "The great lesson," says King, "to be learned from these results is that we must have an abundance of water in order that our crops may avail themselves of the plant food stored in our soils, not that water is everything, but the fertility of the soil counts for naught without it."

The above statements give us some idea of the great and increasing importance of irrigation to the American farmer. Recent investigations on this important subject have given some results of considerable practical value, and it is the purpose of this article to briefly summarize these results.

The greatest profit is derived from irrigation where intensive farming is practiced, In fact, the practice of irrigation naturally leads to intensive farming. In such farming the aim should be to economize all the elements of fertility, to utilize water, fertilizer, labor, etc, to the best possible advantage. If fertilizers are used they will give the best returns if kept in the upper layers of the soil, where they can be fully utilized by the plant. If irrigation is practiced, also, the amount of water applied should not be excessive, otherwise the fertilizing materials are either washed into the lower layers of the soil where they cannot be utilized by the plant, or are entirely removed in the drainage. It thus keeps the valuable fertilizing constituents of the soil within easy reach of the crop. On "alkali" soils, however, under the above conditions the corrosive poisonous alkaline salts would accumulate at the surface to the destruction or great injury of the crop.

Methods of applying irrigation water, especially surface irrigation and subirrigation, have been tested by a number of the experiment stations in both arid and humid regions. The results have generally been unfavorable to subirrigation. The laying of the underground pipes necessary in this system is of course expensive, and, moreover, it is difficult, if not impossible, in subirrigation to obtain a uniform distribution of the water throughout the soil on account of the fact that while water moves up and down in the soil with comparative rapidity it moves from side to side very slowly. The irrigation pipes being out of sight it is impossible to note the movement of the water with accuracy. The soil immediately surrounding the pipes may become excessively wet, while a large proportion of the soil between the pipes is insufficiently irrigated. Moreover, a considerable amount of the water may pass down into the lower layers of the soil without being of the slightest benefit to the crop. King found that a given amount of water was much more effective in increasing the yield of corn when applied by surface irrigation than when applied by subirrigation.

Raine, of the New Hampshire Experiment Station, in experiments with celery on clay loam soil "with water applied both through ditches for surface irrigation and through tiles below the reach of the plow for subirrigation" found that "the latter system required much more water than the former for the same results."

> [A method of tile irrigation which he has found to possess decided advantages over ordinary subirrigation] was to place common porous 2½-inch drain tiles in a continuous row, end to end, on the surface of the soil, vegetables being planted on either or both sides of the line. The tiles were 1 foot long, and by pouring in the water at one end of the line it was distributed at the joints throughout the length desired when the opposite end was stopped up. Take celery as an example crop for irrigation

on uplands. We plant the celery as above stated, and while it is young we have simple surface irrigation; but as the crop grows we bank it up, and finally have the tiles covered, and thus have subirrigation. The tiles are cheap and last indefinitely. When the celery is harvested, the tiles are dug out also and piled up or used for subirrigation in the greenhouse beds. Potatoes and various other crops can be grown in the same way. The celery watered this year grew well and did not rust. Besides this, we were able to water twenty times as much space in the same time as in the ordinary way with ditches. Besides saving time, this plan delivers water where it is most needed, and we have reason to believe is fully as economical with water as with time.

Experiments during two seasons have shown that with this method "the plants did fully as well as in the other systems and with less water."

Where irrigating is to be done on a large scale, it seems to be the consensus of opinion that surface irrigation by means of furrows is undoubtedly the most practical method. In greenhouses and gardens subirrigation by means of tiles may often be found advisable. Furthermore, many soils need drainage and require the laying of tile. On such soil it may be possible to combine drainage and subirrigation economically, and the Wisconsin Experiment Station is at present studying this subject.

Effects of Subsoiling.

Upon the question of subsoiling, the same bulletin has this to say:

"A question of the greatest importance in regions of deficient rainfall or where irrigation is practiced is the storage capacity of the soil for water. When the soil is thoroughly loosened up, the amount of water which it will hold is greatly increased, and the rise of water to the surface and evaporation are checked. Experiments at the Wisconsin and Nebraska Experiment Stations have shown the beneficial effects in these respects of subsoiling. On this point the Nebraska station makes the following suggestions:

Subsoil plowing, although a means of conserving moisture, does not produce it, and is, therefore, not a substitute for irrigation where the rainfall is too small to produce crops.

Where there is a hard, dry subsoil, subsoil plowing is to be recommended.

Where the subsoil is loose, gravelly, or sandy, subsoiling is probably unnecessary, or may even be injurious.

Do not subsoil when the soil is very wet, either above or beneath, as there is great danger of puddling the soil, thus leaving it in worse condition than before. This is one of the reasons why it is better to subsoil in the fall than in the spring.

If the ground be subsoiled in the fall, the winter and spring rains have ample opportunity to soak in, that being the season of greatest rainfall and least evaporation. (In the Florida peninsula the "rainy season" occurs, of course, during the summer months.)

Subsoiling in the spring may be a positive detriment if the subsoil be extremely dry, as in that case the rain water is partially removed from the young plant by the absorption of the bottom soil. If the spring rains were heavy, this would not be a disadvantage.

It is probable that the increased yields on subsoiled lands are mainly, if not entirely, due to the increased amount of water which such land is able to store up for the use of the crop. Subsoil plowing may thus be made the means of greatly extending the area over which crops may be successfully grown without irrigation, and when practiced in connection with irrigation may result in a great saving of irrigation water. As indicated above, however, before deciding upon the advisability of subsoiling it is necessary to ascertain, among other things, the nature and condition of the soil and subsoil."

Interpretation of Analyses.

In order that the analyses given in these pages may be of practical benefit to the farmers it is not enough simply to publish pages of tables which, to the uneducated, will convey no meaning. It is important that information be given that will enable all to derive benefit from a careful study of such tables. Columns of figures set opposite "meaningless names" are of no practical value to the uneducated.

The tables of analyses herein express the percentage composition of the various soils. That is, they tell how many pounds of the various soil constituents are present in each hundred pounds of the sample of air-dried soil taken for analysis. For example, suppose that in reporting the proportion of insoluble residue present in a soil sample the figures 95.8450 are employed: This simply means that in each hundred pounds of the soil (air-dried) there are present ninety-five (and the fraction given) pounds of this insoluble residue, consisting of sand, insoluble silicates, etc. It will also be noticed that in the printed tables the figures are carried out to the fourth decimal place. There were two reasons for so doing. One was that some of the soil constituents occurred in such small proportions that if only two decimals had been employed it frequently would have happened that a soil would fail to show any quantity of a particular element present when, as a matter of fact, several hundred pounds of that element may have occurred in each acre of that soil from the surface to a depth of one foot. Another reason was, the employment of four decimals enables the figures to be converted into a meaning which an ordinary reader, unfamiliar with chemical tables, can readily interpret. If the decimal point is removed, each number given represents so many pounds in a million (or five hundred tons). Then if Prof. Johnson's estimate of four million pounds (two thousand tons) be approximately the weight of the soil on one acre to the depth of one foot, it is easy to ascertain the amount, in pounds, of any soil constituent in a similar area.

Suppose, for instance, that the figures .0583 are employed in reporting the quantity of potash occurring in a soil: This simply means that there are present 583 pounds of potash in each million pounds of soil, and then, since according to Johnson, the average weight of a soil to the depth of one foot on an acre, is four million pounds, and since there were present about 583 pounds of potash in each million pounds, then one acre (four million pounds) would contain 2,332 pounds of this material. The same calculation will apply to every other constituent in the analysis which are reported in four decimals. A more approximate estimate of the quantity of the several constituents present in the sandy soils reported herein, can be had by employing the figures of Stockbridge reported in a previous table and applying especially to sandy soils. Those emplyed above were average figures for different soil types, According to Stockbridge, the approximate weight of a cubic foot of sandy soil is 110 pounds. Then, a similar calculation to the one above will show that an acre of such soil to a depth of one foot will weigh 4,791,600 pounds (instead of 4,000,000 pounds), and the quantity of the several soil constituents will increase proportionately. It should not be forgotten, however, that far the greater proportion of this potash, etc., is in an unavailable form and is likely to remain so for an indefinite period. At present, there is no method by which the chemist can, in his laboratory, ascertain with precision, the amount of the several elements that plants can employ, but it is known that only in the case of virgin soils, in this State, is it ever safe to rely on them, without administering to them fertilizer treatment. And it is not always the case that even the virgin soils are naturally productive, as will be indicated in the subsequent analyses. It will be noticed that in all tables the soil elements are reported in the form of "oxids." This method of reporting analyses is universally employed because of its convenience in affording a simple and uniform method for recording analytical results. Soil constituents do not actually exist in the soil as "oxids," because of their active chemical behavior toward one another. All metalic oxids invariably combine with the soil acids to form chemical salts. Thus calcium oxid and sulphuric acid form calcium sulphate, and the same oxid with carbon dioxid to form calcium carbonate, etc.

There are two points in connection with the estimation of the mineral matter in soils that the chemist must keep in view. First, he must ascertain the total quantity of such matter in the soil, and second, he must determine the proportion of mineral constituents that are more easily brought into solution, and hence are in condition to be appropriated in the growth of plants. A large proportion of the potash, soda, etc., of soils is in the form of complex silicates, formed by the union of these elements with sand, and plant-food in this form is of no value to the agriculturist. It is generally customary to divide the plant-food and silicates of the soil into three classes.

(1) Those silicates which exist in such a state as to require the combined action of strong chemicals and high heat to decompose them. This class possesses at least no immediate value to the farmer, since it will require a number of years for the various disintegrating natural forces to liberate any appreciable quantity of plant food from them.

(2) This class comprises what are known as the zeolitic silicates. In this division the plant food is in a more soluble form, and is dissolved by the chemist in a hot 22.9 per cent hydrochloric acid solution (sp. gr. 1.115). It is believed that hydrochloric acid of this strength represents the limit of the solvent action of the various organic acids of plant roots, etc., and hence, includes all material that can possibly be available to growing crops. The solvents that act upon soils while crops are growing are the acid sap of plant roots and the dissolved mineral and organic salts. In some plants one acid will predominate and in some another. Thus, in lemons citric acid is present, in apples malic acid is

found, and in grapes tartaric acid predominates. Frequently the sap of one plant will contain several acids. Now, since the several organic acids possess varying solvent powers it follows that plants containing different acids will possess different capacities for deriving their food from soils.

Various organic acids of different strengths have been tried in the laboratory with a view to approximating the total solvent action of plants on the soil, among them, citric, tartaric and oxalic acids, but nearly all practical experiments have served to prove that hydrochloric acid of the above strength more accurately approximates results obtained from practical experiments than all others, and hence, it is more universally employed as the solvent for available plant food. It is the soil solution of this acid that is employed in all analyses given in this bulletin.

(3) This class comprises all silicates and other compounds of potash, soda, lime, magnesia, phosphorus, etc., which are easily soluble in the soil water and weak (dilute) organic acids. In this division is included the most available, and hence, the most valuable of the soil ingredients, but, unfortunately, plant food in this form occurs only in very small amounts. Rarely is it the case that more than a few hundredths of a pound of a plant food occur in this form in a hundred pounds of soils.

It is impossible to fix an arbitrary standard by which the chemist can adjudge precisely concerning the fertility of soils. In would be a risky thing for him to do to assert positively that a soil *must* analyze a certain definite quantity of each soil constituent in order to be productive through one or several seasons. As has been stated, in our present state of chemical knowledge he can only predict with a moderate degree of positiveness because of his inability to ascertain the exact amount of any soil element that is present in an available form. It is generally true, however, that if a soil shows a high percentage of all plant food constituents it will prove productive, but on the other hand, it is not true that every soil which shows a low percentage of plant food is unproductive. Here in Florida there are many soils that are apparently very deficient in certain plant food elements, when compared with the soils of other States, and yet the yields obtained from them are entirely satisfactory. These soils may continue to produce good yields for a few years, but there is sure to come a time when they will fail to do so, and then will it be necessary to fertilize them before they can be made to produce. Where there is present only a limited amount of plant food at the most, it is not likely that any great proportion of it exists in a form that will permit of plants employing it in growth, and, even in the case of virgin soils, it cannot be expected that they will last longer than a few years in any event.

Prof. Hilgard, probably the most eminent authority on the Chemistry of soils, has this to say in reference to the quantity of soil elements that should be present before a soil can be regarded as possessing lasting fertility.

"The *lime* percentage should not fall below 0.1 per cent. in the lightest sandy soils; in clay loams not below 0.25 per cent., and in heavy clay soils not below 0.5 per cent; and it may advantageously rise to 1 and even 2 per cent. as a maximum. Beyond the latter figure it seems in no case to act more favorably than a less amount, unless it be mechanically.

"The percentage of *phosphoric acid* is that which, in connection with the lime, seems to govern most commonly the productiveness of our virgin soils. In any of these, less than .05 must be regarded as a serious deficiency, unless accompanied by a large amount of lime. In sandy loams, 0.1 per cent., when accompanied by a fair supply of lime, secures fair productiveness for from eight to fifteen years; with a deficiency of lime, twice that percentage would only serve for a similar time.

"The potash percentages of soils seem, in a large number of cases, to vary with that of 'clay;' that is, in clay soils they are usually high, in sandy soils low; and since subsoils are in all ordinary cases more clayey than surface soils, their potash percentages are almost invariably higher.

"The potash percentage of heavy clay upland soil, and clay loams, ranges from about 0.8 to 0.5 per cent; lighter loams from 0.45 to 0.30 per cent; sandy loams below 0.3 per cent. and sandy soils of great depth may fall below 0.1 per cent. consistently with good productiveness and durability. Virgin soils falling below 0.6 per cent. in potash seem in most cases to be deficient in available potash, its application to such soils being followed by an immediate great increase of production. Sometimes, however, a soil very rich in lime and phosphoric acid, shows good productiveness, despite a very low potash percentage, and conversely, a high potash percentage seems capable of offsetting a low one of lime."

It will be observed that only the lime, phosphoric acid and potash are referred to in the above quotation from Prof. Hilgard. This is because these are the only three mineral constituents that are likely to be deficient, and since all others are generally present in sufficient quantities to last for an indefinite period, it is seldom necessary to give them attention. It is worthy of notice, in this connection, to remark, that, while it is usually the case that soils contain a sufficient store of all mineral plant foods, a careful inspection of the analysis, contained herein, will reveal the fact that many Florida soils appear to be lacking in magnesium, and an application of this element, in appropriate form where certain crops are to be grown doubtless will prove satisfactory. Where a soil seems to be deficient in this element, an excellent way to provide it will be to apply the Double Salt (Sulphate) of Potash and Magnesia, using about twice the quantity that would be required of either high grade Sulphate or Muriate of Potash, for fertilizing. In this way, both elements can be applied simultaneously, since the above salt contains a considerable quantity of each.

The hints, given above, will be of great value in interpreting results, and should be carefully studied and thoroughly understood, before considering the analytical tables.

Soil Analyses.

It is in order now to apply what has been said to the various analyses included in this report. The lack of space will compel us to be as brief as possible with this feature of the bulletin. Where the various soils in a county are of the same character, and almost identical, it will not be necessary to separately consider them in detail in every instance. Many inferences will be left for each individual to interpret for himself, in the light of the information that has been placed before him. Only points worthy of general notice will be considered, and minor details will generally be omitted. In studying the several soils, it is deemed best to disregard county alphabetical arrangement and consider them geographically. Beginning, then, with the southern portion of the peninsula, the soils of the various counties will be studied according to this plan, and the first ones considered will be those of Dade County.

The soils of Dade County may be included under five divisions, as follows:

(1) Dark Sand, (2) Rocky Land, (3) White Sand, (4) Mucks, (5) Prairie.

An average sample of division 4 is included in the chapter devoted to Florida mucks. No sample of prairie soil was sent for analysis.

Nos. 10 and 11 include a soil of the first type, Nos.

DADE COUNTY SOILS.

Type of Soil.	"Dark Sand"		"Rocky"		"Rocky"		"White Sand"	
Station Number	Soil 10	Sub-Soil 11	Surface 14	Sub-Soil 15	Soil 19	Sub-Soil 20	Soil 18	Sub-Soil 17
Coarse Earth	4.83	5.93	7.20	7.40	2.60	7.00	8.80	9.20
Fine Earth	95.17	94.07	92.80	92.60	97.40	93.00	91.20	90.80
Humus	.47	4.55	2.77	.10	.23	.21	.00	.53
Nitrogen	.0126	.0602	.1666	.000	.0182	.0042	.0070	.0098
Moisture at 100°C.	.1720	1.7840	1.2160	.0380	.1660	.1720	.0180	.1640
FINE EARTH.								
Insoluble Residue	97.8770	89.7625	87.7215	99.0850	98.0255	96.5225	98.7302	98.1210
Potash (K_2O)	.0965	.0183	.0043	.0024	.0178	trace	trace	.0053
Soda (Na_2O)	.0861	.1362	.0812	.0748	.0804	.1046	.0649	.0631
Lime (CaO)	.0250	.0150	.1275	.0425	.0725	trace	.5500	.0550
Magnesia (MgO)	.0090	.0450	.0612	.0108	.0351	.0387	.0036	trace
Ferric oxid (Fe_2O_3)	trace	.2941	.0278	.0914	.2044	.6519	trace	.1590
Alumina (Al_2O_3)	.0185	.3064	.0682	.0162		1.0363	.0921	.4038
Phosphorus Pentoxid (P_2O_5)	.0240	.0320	.0240	.0224	.0256	.0268	.0304	.0272
Chlorin	trace	trace	trace	trace	trace	.0483	trace	trace
Sulphur Trioxid (SO_3)	.0428	.0137	.0103	.0086	.0086	.0103	.0068	.0471
Carbon Dioxid (CO_2)	.0000	.0000	.0000	.0000	.0000	.0000	trace	.0550
Water and Organic Matter	1.9780	9.3768	11.4600	.6620	1.5301	1.5606	5.220	1.0635
Total	100.1569	100.0000	99.5860	100.0161	100.0000	100.0000	100.0000	100.0000

14 and 15 and 19 and 20 are samples of the second division, and Nos. 18 and 17 of the third. The samples were collected by Messrs. F. A. Soop, F. P. Wilson and E. Lee, all residing near Lemon City, and are types of the prevailing soils of the county. Nos. 10 and 11 constitute an uncultivated soil which was taken from what appeared to be an old channel from the Everglades. The surface of this soil is very dark. The timber growing upon it is comparatively small, consisting of scrub oak, huckleberry, grape vines, etc. There is also a somewhat limited growth of palmetto (both saw and cabbage), and the soil is fairly covered with a coarse, swamp grass. The sub-soil was very compact and exceedingly difficult to disintegrate, after drying, and at a depth of from two to three feet a sunken shaft exposed water in considerable quantities. This soil appears less deficient in potash than in either phosphoric acid, lime or nitrogen. Far the larger proportion of the potash is in the surface soil, while the excess of both nitrogen and phosphoric acid occurs in the sub-soil. It is deficient in all plant-food constituents that it is usually necessary to apply, and should such a virgin soil prove fairly productive at first, it can not be expected to continue fertile any great length of time without fertilization, especially if devoted to trucking and fruit growing. When employed for these purposes, liberal fertilization from the beginning will doubtless prove profitable.

Nos. 14 and 15 and 19 and 20 (virgin rocky soil), taken from the Biscayne Bay region, appear to be exceedingly deficient in potash, but contain considerably more lime than the previous sample, and about the same quantity of phosphoric acid. The occurrence of these latter constituents in these proportions may render this type of soils as productive as the preceding type in the beginning, but like it, it cannot continue to produce satisfactorily for any great length of time without liberal applications of fertilizer. In this type, the soil proper extends to a depth of twelve to fourteen inches, and from this depth a change of color appears, the greyish sand becoming whiter with depth. Commenting on this soil, Mr. Soop writes: "The 'Rocky Soil' produces the densest growth of palmetto, both saw and small cabbage, also, of scrub oak, comptie, etc., as well as very large pine timber."

Nos. 18 and 17 (White Sand) were forwarded by Mr. E. Lee, of Lemon City. Unlike the "Rocky" soil, no rocks appear on the surface of this land, but are found at depths, ranging from two to ten feet. The timber growing upon it is smaller than that upon the "Rocky," and much less palmetto is noticed growing upon it, and the growth of grass is also very limited.

This soil contains far less humus than the preceding types, and crops growing upon it will doubtless suffer much more from drouths. It is exceedingly deficient in nitrogen and potash, less so in phosphoric acid, while its per cent. of lime (especially in the case of the soil proper) is far larger than in any other type previously reported. The per cent. of iron oxid and magnesia are likewise noticeably small in this soil (as well as in some others) and experiments, with a view to supplying these deficiencies, would seem desirable. Magnesia, though, for general purposes, is not much regarded as a plant-food. A growth of beggar-weed, velvet bean, or ordinary field pea upon this soil, would increase the humus supply, as well as that of nitrogen, thus greatly improving it and rendering the purchase of a large amount of a costly nitrogenous fertilizer unnecessary. Reference to the table of averages of the different counties will show that the soils of Dade County, as a whole, are, as regards the three chief essentials, most deficient in potash and least in nitrogen. They are, at the same time, more or less deficient in all. As regards lime, they come just within the limit prescribed by Hilgard, and contain the average amount of this material usually found in the average sandy soils of the peninsula. Except in case of the type designated, "White Sand," they seem fairly well supplied with humus. It may often be the case that those types of soil showing relatively large supplies of humus, are somewhat sour. This can be remedied, either by thoroughly plowing and exposing the soil to some depth, thus allowing a more ready action of the air, or, else, more rapidly, by administering, in such cases, small applications of water-slaked lime. These suggestions should be sufficient to enable every thinking farmer to become somewhat intimate with his soil and its requirements.

In reference to the samples of Lee County soils given in the table, it may be well to state in the beginning that sample No. 29, (General Sub-soil) is the sub-soil to each of the other numbers except No. 1. The collector reported that the same character of sub-soil prevailed throughout the different areas from which the several samples were taken. All samples save No. 1 were selected from various portions of the Experiment Station at Myers.

Practical experience has demonstrated that there is much land in Lee County more fertile than any found on the Experiment Station. Unfortunately, the soils from the station are not virgin, still, although they have been cultivated, none of them, except No. 25 (Best Rye) has ever received any fertilizer.

Sample No. 1 was sent on by Mr. B. H. Barfield, of Marco. This sample is especially noticeable for its high per cent of both phosphoric acid and lime. It is also quite rich in nitrogen and contains a liberal supply of humus. It appears to be deficient only in potash, and in the presence of such a large supply of phosphoric

LEE COUNTY SOILS.

TYPE OF SOIL.		"Best Rye."	"Peach and Plum."	"Northeast Portion."	"General Sub-soil."	"Satsuma."
Station Number	Soil 1	Soil 25	Soil 26	Soil 28	Sub-soil 29	Soil 59
Coarse Earth	17.40	4.80	4.20	3.00	1.20	2.20
Fine Earth	82.60	95.20	95.80	97.00	98.80	97.80
Humus	3.47	1.37	.80	.93	.00	1.27
Nitrogen	.4914	.1162	.0714	.0630	.0014	.0686
Moisture at 100°C	4.0460	.3300	.2100	.1820	.0460	....
FINE EARTH.						
Insoluble Residue	65.4090	96.4305	96.2090	97.3085	99.5275	95.3035
Potash (K_2O)	.0164	.0058	trace	.0125	.0087	.0024
Soda (Na_2O)	.3307	.0242	.0277	.0915	.0695	.0354
Lime (CaO)	6.6050	trace	.0725	.0000	.0000	.0700
Magnesia (MgO)	.0290	.0299	.0198	.0117	.0027	.0261
Ferric oxid (Fe_2O_3) Alumina (Al_2O_3)	4.4140	.0592	.0329	.0688	.0600	.0647
Phosphorus pentoxid (P_2O_5)	2.5630	.0208	.0496	.0112	trace	.0128
Chlorin	.0536	trace	trace	trace	trace	trace
Sulphur dioxid (SO_3)	.0540	.0172	.0188	trace	.0034	.0086
Carbon dioxid [CO_2]	4.5940	.0000	.0000	.0000	.0000	.0000
Water and organic matter	16.7740	3.4124	3.4140	2.4958	.3360	4.4765
Total	100.8427	100.0000	99.8443	100.0000	100.0078	100 0000

acid and lime, it may be that it will prove quite productive for a while without any fertilizer application. More likely, though, a liberal dressing of potash would increase the yield quite perceptibly. This soil gave an alkaline reaction with test paper, which was to be expected, since it was thickly interspersed with fine shell particles. It has never been cultivated, but after an addition of potash, it certainly ought to prove quite productive after being put in proper tilth.

The requirements of the remaining soils can be inferred from what has been already said relative to preceding analyses. Brieflly stated, though, No. 25 is shown to be most deficient in lime and potash, and somewhat so in phosphoric acid. It appears to be well supplied with all other plant-food material. No 26, though apparently less fertile than 25, appears to be most deficient in the same materials and to require the same general treatment.

Nos. 28 and 59 appear to be exceedingly poor, and will doubtless require a complete fertilizer, proportioned so as to meet the particular requirements of the crop to be grown. They appear to be fairly well supplied with humus, but it is entirely probable that a growth upon them, of one of the *legumes* previously referred to would prove beneficial both as regards enriching the soil and improving its tilth. As is indicated by the names, Nos. 25 and 26 are soil areas lately devoted to growing rye and fruits respectively.

Sample No. 64, of which only the surface soil is given, being only one sample, can hardly be said to be typical of all the farming pine lands of the county. As a whole, the high pine lands of the county, however, are probably similar in composition to those of other adjacent counties, and will require similar treatment. The method for conducting practical soil test experiments, given in

DESOTO COUNTY SOILS.

TYPE OF SOIL.	Salt Marsh	Salt Marsh	Pine Land
Station Number	Soil 4	Sub-soil 5	Soil 64
Coarse Earth	1.10	1.00	4.00
Fine Earth	98.90	99.00	96.00
Humus	.69	.11	1.76
Nitrogen	.0994	.000	.2060
Moisture at 100°C	.5960	.0940	.9600
FINE EARTH.			
Insoluble Residue	95.6575	99.3375	90.9210
Potash [K_2O]	.0212	trace	.0072
Soda [Na_2O]	.4844	.1841	.0297
Lime [CaO]	.0750	.0325	.0000
Magnesia [MgO]	.1125	.0189	.0369
Ferric Oxid [Fe_2O_3]	.0914	.0437	.5812
Alumina [Al_2O_3]	.1426	.0413	1.1410
Phosphorus pentoxid (P_2O_5)	.0160	trace	.0928
Chlorin	.3657	.1207	trace
Sulphur Trioxid [SO_3]	.3695	.0300	.0000
Carbon Dioxid [CO_2)	.0000	.0000	.0000
Water and Organic Matter	3.1240	.3900	7.2920
Total	100.4598	100.1987	100.1018

subsequent pages, will enable every one interested to ascertain the needs of the several types, and such experiments should invariably be undertaken.

Sample Nos. 4 and 5 were sent on by Mr. Carl Troil, a resident of Wetumpka, Ala., who owns land near Punta Gorda, Fla. The soil is virgin, and the growth upon it is chiefly marsh grass and no timber. It is located near salt water. The high per cent. of sodium and chlorin shown in the analysis indicate that there is an excess of common salt (sodium chlorid) in this soil—a sufficient quantity to prove highly injurious to growing crops. Indeed, it is possible that crops will refuse to make a substantial growth upon it, without it can be freed from the objectionable salt accumulation by drainage. It is believed that if as much as one part of chlorin, per thousand, occurs in a soil, it will prove injurious, and it is shown in the analysis that much more than this amount is present. It is exceedingly rare to find an excess of chlorin occurring in Florida soils, save in the case of salt marshes, and for that reason the estimation of chlorin in nearly all soil samples really might have been omitted. As regards the essential fertilizing constituents, the sample appears to be most in need of phosphoric acid, and next of potash. Even after the excess of salt is removed from it by drainage, it cannot be expected that it will remain long fertile, if fertile at all, if subjected to a continuous system of cropping. Sample 64 is of surface soil only, and is fairly representative of the surface soils of the high pine lands comprised in a radius of thirty-three miles of Wauchula. "The surface soil is gray to a depth of four inches, and, after that," writes Mr. Clavel, who sent on the sample, "the color changes to dark brown and continues so for about nineteen inches." The timber growing upon the land is high pine, huckleberry bushes, etc. The soil also contains considerable growths of wire-grass, wild oats, wild sweet peas, myrtle and saw palmetto. This sample is shown to be quite deficient in both lime and potash. It contains considerably more phosphoric acid than either of the above, but, in the absence of lime, it is not likely that much of it is available. Probably this soil would respond quite well to applications of acid phosphate and potash—the former would provide both, lime and phosphoric acid. It appears to be fairly well supplied with nitrogen, and it is not likely that an addition of this element will be necessary.

Sample A was analyzed about two years ago, and it was not intended for publication in this bulletin. Unfortunately, several important determinations were omitted. It is believed, nevertheless, that its publication even in its present form, at this time will be of some benefit, since the sample is typical of a large track of virgin soil lying near the gulf coast in Manatee county, and the analysis presents points worthy of consideration. Repeated efforts to secure typical Manatee county soils for analysis in connection with this bulletin resulted in failure. The present sample connot, of course, be said to represent the typical Manatee soils. It is simply a type of what is known locally as "Hammock Marl Land," and which occurs in large areas in the section from which it was taken. It is generally regarded by the farmers of that section as of little or no value. The analysis seems to indicate that, with proper treatment, this soil can be made to compare favorably with the best hammock lands of the State. It seems quite well supplied with phosphoric acid, and while the nitrogen estimate is not shown, it is likely, from the proportion of volatile matter (chiefly organic) present, that the soil is fairly well supplied with this element. The quantity of potash is somewhat deficient, though not so much so as was found to be

MANATEE COUNTY.

TYPE OF SOIL.	Ham'ock Marl Land
Station Number	Soil and Subsoil A
Coarse Earth	
Fine Earth	
Humus	
Nitrogen	
Moisture at 100°C	1.4080
THE FINE EARTH ANALYZED.	
Insoluble Residue	56.3440
Potash [K_2O]	.0467
Soda [Na_2O]	.4384
Lime [CaO]	21.1700
Magnesia [MgO]	.1760
Ferric oxid [Fe_2O_3]	1.9850
Alumina [Al_2O_3]	
Phosphorus Pentoxid [P_2O_5]	.2140
Chlorin	.4149
Sulphur trioxid [SO_3]	.0000
Carbon dioxid [CO_2]	15.4300
Volatile matter	2.3000
Total	98.5190

the case with many other soils. The two most noticeable characteristics of the sample are the high per cents of lime and sodium chlorid or common salt—most of the chlorin being in combination with with sodium to form this material. Where the location of the land is favorable and drainage (and irrigation, if necessary) can be accomplished at moderate expense, the excess of salt can be removed by this means. Then, by growing forage crops, with heavy foliage (such as melilotus) upon the land for several successive years, it will be found that it will be very greatly improved. Indeed, such crops, even in the absence of drainage and irrigation, will greatly benefit it. This land will doubtless require potash fertilization before any other, but in the presence of so much lime, the supply even of available potash may last for several years under ordinary cropping. Should the quantity of lime be so large as to prove injurious to growing vegetation, under the system recommended above, and by growing such crops as the clovers upon it, and feeding and pasturing the crop, much of the excess of it will be gotten rid of each year.

This sample, not being a typical soil will not be included in the table of averages to be inserted later on.

It was forwarded to the laboratory by Mr. Kline O. Varn, of Venice, Fla. It was taken to a depth of ten inches and, as has been stated, is a fair average of this particular type of soils.

Samples Nos. 12 and 13 were sent on by S. T. Carrow, of Sewall's Point. They are a type of soil (high hammock) usually employed in Brevard County, for growing pineapples. They are not virgin soil. Originally they were covered with a heavy growth of hard wood, hickory, oak, bay, etc. Usually, it produces perfect pines, with proper fertilization, but here and there in the field, occur patches upon which they refuse to thrive. After the first year, they begin to die, and eventually they appear to entirely starve. Sample No. 12 is from the portion of the field where the plants grow perfectly, and No. 13 is taken from a spot where they refuse to thrive. So far as the chief constituents are concerned, the only very noticeable difference in the composition of the two samples appears to be in the lime, and, to a less extent, in the phosphoric acid, in which No. 12 appears to have some advantage. This sample is slightly more deficient in potash than No. 13, but contains more magnesia, iron, alumina, etc. Fertilizer soil tests will provide the only definite means for ascertaining if it is due to some plant-food deficiency. If such tests fail to solve the problem,

BREVARD COUNTY SOILS.

TYPE OF SOIL.	"Field"	Patches	"Saw Palmetto Scrub"		"Yellow Soil"		" White Soil"		General Sub-soil	Orange Soil
Station Number	Soil 12	Soil 13	Soil 21	Sub-soil 22	Soil 38	Sub-soil 39	Soil 40	Sub-soil 41	Sub-soil 37	X
Coarse Earth	21.00	24.90	3.20	4.00	11.40	7.90	12.20	5.20	11.70	....
Fine Earth	79.00	75.10	96.80	96.00	88.60	92.10	87.80	94.80	88.30	....
Humus	.24	.21	.71	.07	.18	.02	.16	.01	.12	....
Nitrogen	.0378	.0252	.0742	.0126	.0182	.000	.0042	.000	.000	.0261
Moisture at 100° C	.4000	.2940	.4880	.3140	.1820	.1000	.0400	.0080	.0925	.2100
FINE EARTH.										
Insoluble Residue	97.5085	98.2100	92.3635	82.8206	97.2875	97.8545	98.6490	99.4480	98.2240	98.1951
Potash (K_2O)	.0086	.0111	.0612	.0564	trace	.0077	.0034	.0048	trace	.0198
Soda (Na_2O)	.0510	.1285	.1911	.2150	.0516	.0492	.0714	.0344	.0781	.0120
Lime (CaO)	.2100	.1075	2.2325	7.5250	.0400	.0000	.0000	.0000	.0000	.1150
Magnesia (MgO)	.0225	.0099	.0207	trace	.0090	.0990	.0634	.0036	.0243	.0197
Ferric Oxid (Fe_2O_3)	.2345	.1312	.6156	.3375	.8784	.8602	.1472	.3180	.7750	.4360
Alumina (Al_2O_3)	.1169	.0596				.4011	.1328	.0935	.3688	.2440
Phosphorus pentoxid (P_2O_5)	.0336	.0192	.0544	.0672	.0416	.0637	trace	.0160	.0112	.0333
Chlorin	trace	trace	.0086	trace	trace	trace	trace	trace	trace	trace
Sulphur Trixod (SO_3)	.0145	.0103	trace	trace	trace	.0060	trace	trace	trace	.0530
Carbon Dioxid (CO_2)	.0000	.0000	1.6060	5.4280	.0000	.0000	.0000	.0000	.0000	.0000
Water and Organic Matter	1.7999	1.3127	2.8464	3.5500	1.8600	.6400	.7860	.1600	.6250	.8010
Total	100.0000	100.0000	100.0000	100.0000	100.1681	99.9840	99.8532	100.0783	100.1064	99.9550

then the trouble likely arises from some deseased condition of the soil which it is not in the province of the chemist to discover. Probably, in such event, the bacteriologist may suggest an efficient remedy. Samples 21 and 22 were forwarded by Mr. L. B. Dawson, of Narrows. They are from comparatively new land which originally was covered with scrub palmetto. It has never succeeded in producing successful yields. The quantity of lime in this sample is noticeably large. It is hardly likely, though, that failure to produce is due to this rather excessive quantity of lime.

It appears to be somewhat deficient in each of three essential plant-foods, as well as in humus, though, as regards fertility, it appears to be superior to many other Brevard soils.

Nothing unusual is noticed in any other of the Brevard analyses, and therefore, further comment is deemed unnecessary, except to remark that No. 37 is taken below to the two preceding soils and sub-soils at a depth of four feet.

Samples 47 to 52, inclusive, were sent on by Mr. R. E. Rose, of Kissimmee. In his letter referring to them he divides the soil types and estimates the proportions of the several soils occurring in the county as follows:

1. Pine Ridge..................	15 per cent.
2. Flat woods..........	60 "
3. Hammock...............	5 "
4. Muck soils.................	20 "

Nos. 47 and 48 are an average sample of soil and sub-soil of the first type. The principal growth upon it is tall pine with scattering oak, willow, sumach, and wire grass. The portion rejected on the sieve consisted almost wholly of roots, leaves, etc. This sample seems to be deficient in all the principal fertilizing elements, including lime, and it cannot be relied upon to produce satis-

OSCEOLA COUNTY SOILS.

TYPE OF SOIL.	"Pine Ridge."		"Flat Woods."		"Hammock."	
Station Number	Soil 47	Sub-soil 48	Soil 49	Sub-soil 50	Soil 51	Sub-soil 52
Coarse Earth	.90	.20	1.10	.40	.80	.20
Fine Earth	99.10	99.80	98.90	99.60	99.20	99.80
Humus	.38	.97	1.02	.38	.82	.92
Nitrogen	.0350	.0182	.0490	.0014	.0658	.0210
Moisture at 100°C	.1860	.3300	.3800	.1500	.4000	.3360
FINE EARTH.						
Insoluble Residue	97.2280	97.7060	96.6970	98.7755	95.9345	97.2820
Potash [K_2O]	.0077	trace	.0073	trace	trace	trace
Soda [Na_2O]	.0067	.0278	.0438	.0172	.0318	.0331
Lime [CaO]	.0225	.0000	.0150	.0000	.0600	trace
Magnesia [MgO]	.0144	.0063	.0252	.0054	.0234	.0153
Ferric Oxid Fe_2O_3] }	.0718	.1937	.0854	.2712	.0581	.2325
Alumina [Al_2O_3] }		.2183		.1733		.4426
Phosphorus pentoxid [P_2O_5]	.0032	.0080	.0096	.0080	.0144	.0624
Chlorin	trace	trace	trace	trace	trace	trace
Sulphur trioxid [SO_3]	.0060	trace	trace	.0042	.0120	.0368
Carbon dioxid [CO_2]	.0000	.0000	.0000	.0000	.0000	.0000
Water and organic matter	2.7980	1.9500	3.1167	.8620	3.9460	1.9280
Total	100.1583	100.1101	100.0000	100.1168	100.0802	100 0327

factory yields, at least for any length of time, without it receives liberal fertilizing.

Nos. 49 and 50 constitute a soil and sub-soil of the representative flat woods virgin soil of the county. The chief vegetation growing upon it is pine, scrub-palmetto and wire grass. It exhibits approximately the same plant-food deficiencies as the preceding sample and should receive similar treatment.

Nos. 51 and 52 are the soil and sub-soil of the average hammock land of the county. The growth upon it is hickory, live oak, water oak and mulberry. This sample contains more nitrogen, phosphoric acid and lime than the preceding samples, and ought to prove more lasting without fertilizer applications. It should require potash fertilization before any other, since the quantity of this found was too small to admit of weighing. The muck soils will be commented upon in the chapter on mucks to be inserted later.

Samples 42, 43, 44, 45 and 46 were collected by Mr. J. H. Tatum, of Bartow. No. 42 is an almost pure white sand. There is a luxuriant growth of live oak, hickory, cherry, wild orange, pine and cabbage palmetto upon it. It includes both soil and sub-soil to a depth of two and a half feet. The only orange grove in Polk County, not frozen in 1895, adjoins the land from which this soil sample was taken and was of a similar character. The chemical analysis fails to throw any light upon this peculiar circumstance. More likely, the cause will be found in the favorable location of the grove as regards exposure, proximity to water, method of fertilization etc. The analysis shows this soil to be very deficient in all the essential plant-food elements which it frequently is necessary to apply.

Nos. 43 and 44 are samples of soil and sub-soil, in each case, and in both instances the sample was taken to

POLK COUNTY SOILS.

TYPE OF SOIL.	"No. 8."	"No. 12."	"No. 3."	"No. 6A and No. 6B."	
Station Number	Soil 42	Soil 43	Soil 44	Soil 45	Sub-soil 46
Coarse Earth	2.31	3.62	4.89	2.50	1.73
Fine Earth	97.69	96.38	95.11	97.50	98.27
Humus	.02	.50	1.15	.77	.18
Nitrogen	.0042	.0126	.294	.0126	.0042
Moisture at 100°C	.0300	.4040	1.0360	....	.2340
FINE EARTH.					
Insoluble Residue	99.4830	95.2190	89.3950	95.8240	96.8940
Potash [K_2O]	.0038	trace	trace	.0028	trace
Soda [Na_2O]	.0365	.0252	.0265	.0201	.0344
Lime [CaO]	.0000	.0125	.1125	.0175	.0250
Magnesia [MgO]	.0090	.0581	.0990	.0414	.0477
Ferric Oxid [Fe_2O_3]	.0986	.8525	1.0850	.3332	.6432
Alumina [Al_2O_3]		1.0532	1.7125	1.0281	.9678
Phosphorus pentoxid [P_2O_5]	.0064	.2768	2.4000	.2112	.2240
Chlorin	trace	trace	trace	trace	trace
Sulphur trioxid [SO_3]	.0000	trace	trace	.0051	trace
Carbon dioxid [CO_2]	.0000	.0000	.0000	.0000	.0000
Water and organic matter	.3540	2.3860	5.0660	2.5320	1.1520
Total	99.9913	99.8783	99.8965	100.0154	99.9881

POLK COUNTY SOILS.

Type of Soil.	High Sand Hill		Level Sandy Land	
	Soil	Sub-Soil	Soil	Sub-Soil
Station Number	55	56	57	58
Coarse Earth	8.83	7.16	6.83	6.00
Fine Earth	91.17	92.84	93.17	94.00
Humus	.54	.17	.38	.20
Nitrogen	.0182	.0014	.0154	.0014
Moisture at 100°C	.1800	.1000	.1400	.0680
FINE EARTH.				
Insoluble Residue	97.4560	98.3770	98.2610	98.7800
Potash (K_2O)	trace	trace	trace	.0077
Soda (Na_2O)	.0234	.0344	.0384	.0041
Lime (CaO)	.0125	.0000	.0000	.0000
Magnesia (MgO)	.0261	.0117	.0162	.0072
Ferric Oxid (Fe_2O_3)	.4678	.3487	.2712	.1395
Alumina (Al_2O_3)		.1912	.3898	.3373
Phosphorus Pentoxid (P_2O_5)	.0272	.0176	.0240	.0032
Chlorin	trace	trace	trace	trace
Sulphur Trioxid (SO_3)	trace	.0000	.0000	.0000
Carbon Dioxid (CO_2)	.0000	.0000	.0000	.0000
Water and Organic Matter	2.0140	1.0194	.9994	.6560
Total	100.0270	100.0000	100.0000	99.9350

a depth of two and a half feet. As will be seen, No. 44 contains an abundance of phosphoric acid and a fair supply of lime. It is not likely that this soil will need any phosphoric acid for quite a while, since enough of this element will doubtless become available to supply all needs. It contains only a small supply of nitrogen and is exceedingly deficient in potash.

No. 43 appears quite well supplied with phosphoric acid, but the lime supply is shown to be quite limited. Its supply of available acid cannot last very long without steps are taken to render it available, since the lime naturally existing in the soil is very limited. It is deficient in nitrogen and very much so in Potash, and both of these must be supplied before many crops are harvested.

Nos. 45 and 46 are the soil and sub-soil of another sample taken at a similar depth. Comment upon these analyses is unnecessary, for what has previously been said in connection with other soil samples will furnish the necessary information to interpret them.

Samples 55-58 (inclusive) were forwarded by Mr. Charles G. Wilson, of Winter Haven.

Nos. 55 and 56 are representative types of the soil and sub-soil, respectively, of the high sandy hills of that vicinity. The location selected for taking the sample was from thirty to forty feet above Lake Elbert. The principal growth upon it is small pine, with more or less oak, willow, etc., scattered here and there. It also has an undergrowth of wire grass, wild oats, milk weeds, etc.

It appears to be deficient in all plant-food essentials and most so in potash.

Samples 57 and 58 are the soil and sub-soil of a more level location, taken lower down than the previous sample, and at a depth of from twelve to fifteen feet above the lake. A clay sub-soil is found at a depth of five feet from the surface. This soil will require similar treatment to that previously given.

The muck soils of Polk County will be considered in a subsequent chapter devoted to the muck soils of the peninsula.

Samples Nos. 75 and 76 were forwarded by Mr. J. L. Young of Plant City. The sample is virgin soil, collected about one-half mile from the depot. The growth upon it is pine, small oak and wire grass. A clay subsoil occurred at a depth of four feet. The soil is well supplied with humus and contains a fair supply of nitrogen. It contains a large supply of phosphoric acid and lime, and it is not likely to require an application of either of these latter materials in quite a while. It is deficient in potash and is sure to become exhausted of this element earlier than any other when subjected to cultivation.

Samples Nos. 116, 117 and 118 were forwarded to the Laboratory by Hon. F. E. Harris of Ocala. The samples were selected in the vicinity of Clear Water, Fla. Nos. 116 and 117 are a sample of cultivated soil which produces satisfactory yields when fertilized, and No. 118 is selected from an unproductive patch in the same field which fails to respond to the same fertilizer application. The writer is not aware of the variety of fertilizer that has been administered, but the analysis shows the soil (Nos. 117 and 118) to be somewhat deficient in humus, nitrogen, and lime, though there may be enough of the latter to render an application of phosphoric acid unnecessary for a little while, since this acid is shown from the analysis to be fairly well supplied. The sample is shown to be quite deficient in potash, and this element in some form should be supplied. Sample No. 118 is a mixture of soil and sub-soil. It is most deficient in potash, quite so in phosphoric acid, and somewhat so in nitrogen.

HILLSBORO COUNTY SOIL.

TYPE OF SOIL.	"Virgin Pine Land."		"Orange Grove."		"Unproductive Patch."
Station Number	Soil 75	Sub-soil 76	Soil 116	Sub-soil 117	Soil 118
Coarse Earth	5.20	3.40	2.33	2.16	1.66
Fine Earth	94.80	96.60	97.67	97.84	98.34
Humus	1.50	1.22	.25	.36	.33
Nitrogen	.1106	.0238	.0770	.0266	.0322
Moisture at 100°C	.7700	.5880	.4000	.3500	.1460
FINE EARTH.					
Insoluble Residue	90.3250	92.5155	95.6830	97.2115	98.0175
Potash [K_2O]	.0028	trace	.0023	trace	trace
Soda [Na_2O]	.0439	.0371	.0547	.0569	.0636
Lime [CaO]	.2025	.0725	.2650	.0250	.0650
Magnesia [MgO]	.0693	.0666	.0072	.0090	.0126
Ferric Oxid [Fe_2O_3]	1.3175	.7750	.6495	.9739	.5240
Alumina [Al_2O_3]	1.7667	2.7910			
Phosphorus pentoxid [P_2O_5]	.3408	.3040	.0880	.1136	.0160
Chlorin	trace	trace	trace	trace	trace
Sulphur trioxid [SO_3]	.0000	.0000	trace	trace	trace
Carbon dioxid (CO_2)	.0000	.0000	.0000	.0000	.0000
Water and organic matter	5.7700	3.8400	3.0200	1.5640	1.2740
Total	99.8385	100.4017	99.7697	99.9539	99.9727

Should the other soil of the field fail to continue to produce after the treatment suggested, it may prove advantageous to administer to it a slight dressing of gypsum.

PASCO COUNTY SOILS.

Type of Soil.	Sandy Soil	
Station Number	Soil 73	Sub-Soil 74
Coarse Earth	2.50	1.20
Fine Earth	97.50	98.80
Humus	1.23	.71
Nitrogen	.0602	.0210
Moisture at 100° C	.6120	.2700
FINE EARTH.		
Insoluble Residue	93.2840	96.6105
Potash (K_2O)	.0048	trace
Soda (Na_2O)	.0595	.0106
Lime (CaO)	.0250	.1450
Magnesia (MgO)	.0405	.0115
Ferric Oxid (Fe_2O_3)	.6510	.5037
Alumina Al_2O_3)	.7380	.5628
Phosphorus Pentoxid (P_2O_5)	.1360	.1360
Chlorin	trace	trace
Sulphur Trioxid (SO_3)	.0000	.0000
Carbon Dioxid (CO_2)	.0000	.0000
Water and Organic Matter	5.1240	2.0420
Total	100.0628	100.0221

It is unfortunate that it was found impossible to secure representative samples of virgin sandy soils from this county. It was only possible to secure one sample from Pasco, and this was of cultivated soil. The collector failed to comply with instructions to collect the sample from typical virgin soil. The sample was forwarded by Mr. J. S. Goss of San Antonio. It was taken from an old corn field, covered at the time with a growth of beggar-weed, and grass. It is quite well supplied with phosphoric acid and lime and contains a moderate supply of nitrogen. It is fairly well supplied with humus and is deficient in potash. It seems to need most a potash fertilizer and next a nitrogenous one. The soil was taken to a depth of eight inches and the sub soil to a depth of two feet, when a stratum of clay was encountered.

Samples 31 and 32 were forwarded by Mr. George H. Wright, of Orlando. This soil was taken from cleared pine land (virgin), and the soil proper was collected to a depth of one foot. The sub-soil was then taken to a depth of two feet. This soil seems to be best supplied with phosphoric acid, though the supply of lime is not sufficient to insure the necessary quantity of this acid remaining available for any great length of time. It is most deficient in potash and, next, in nitrogen. Probably a growth of beggar-weed, or, else, of velvet bean, would be an admirable way to supply the necessary nitrogen, since the supply of humus is shown to be somewhat deficient.

Nos. 60 to 63 (inclusive) are from Mr. George Frost, of Altamonte Springs. Nos. 61 and 62 were collected from land about a mile and a half southwest of the Station. It was cleared of pine timber about twenty years ago. It now contains a growth of scrub-oak, willow, black-jack, etc. The undergrowth is chiefly wire-grass. For the past fifteen years, the grass has been burnt off annually. The analysis shows it to be deficient in all fertilizing materials, but, least of all, in phosphoric acid.

Nos. 62 and 63 constitute a soil and sub-soil of pine land, covered with a growth of pines from eight to eight-

ORANGE COUNTY SOILS.

TYPE OF SOIL.	"Pine Land."		"Origin'l Pine Land."		"Good Pine Land."		"Inferior Pine Land."
Station Number	Soil 31	Sub-soil 32	Soil 60	Sub-soil 61	Soil 62	Sub-soil 63	Y
Coarse Earth	2.20	.80	11.20	11.20	10.90	10.00	
Fine Earth	97.80	99.20	88.80	88.80	89.10	90.00	
Humus	.72	.19	.33	.17	.16	.12	
Nitrogen	.0490	.0098	.0042	.0014	.0014	.0014	.1100
Moisture at 100°C	.3000	.1340	.1640	.1300	.1300	.0800	.6808
FINE EARTH.							
Insoluble residue	95.3470	97.6165	98.0375	98.3745	98.7165	99.0550	96.4261
Potash (K_2O)	trace	trace	trace	.0067	.0193	.0019	.0160
Soda (Na_2O)	.0940	.0318	.0304	.0049	.0315	.0169	.0084
Lime (CaO)	.0275	trace	.0000	.0000	.0000	.0000	.0624
Magnesia (MgO)	.0369	.0342	.0270	.0108	.0036	.0027	.0175
Ferric oxid (Fe_2O_3)	.8835	.4030	.2325	.2092	.0728	.3024	.3902
Alumina (Al_2O_3)	.3162	.7170	.5184	.6140			.6950
Phosphorus pentoxid (P_2O_5)	.1328	.0725	.0816	.0768	.0272	.0176	.1175
Chlorin	trace	trace	trace	trace	trace	trace	trace
Sulphur trioxid (SO_3)	.0086	.0077	.0000	.0000	.0000	.0000	.0180
Carbon dioxid (CO_2)	.0000	.0000	.0000	.0000	.0000	.0000	.0186
Water and organic matter	2.8800	1.0800	1.0960	.8300	1.1291	.6035	2.1300
Total	99 7295	99.9627	100.0234	100.1269	100.0000	100.0000	100.0097

een inches in diameter. It is very similar in composition to the preceding sample, though it is designated by the sender "Good Pine Land."

Sample Y. was analyzed by Prof. Norman Robinson, formerly State Chemist. It was stated by him to be second class pine land of Orange County. Compared with analyses of other pine lands of this county, made in this laboratory, it will be seen that this sample, on the whole, is somewhat superior to some others. The analysis includes both, soil and sub-soil. Further comment upon this analysis is deemed unnecessary. The muck soils of Orange County will be considered in the chapter devoted to this type of soils. It may be well to note here, also, that analyses of samples of muck soil from Lake County will be given in the same chapter. No samples of sandy soil were forwarded from this latter county.

Nos. 6, 7, 8 and 9 were forwarded by Hon. C. F. A. Bielby (now deceased), of DeLand. Nos. 6 and 7 are the soil and sub-soil, respectively, of "Grey Hammock" land. The timber upon it consists of hickory, live and other oaks, magnolia, bay, etc. This soil occurs in Volusia county in patches, varying in size, from ten to five hundred, or, even one thousand acres, and is surrounded by flat woods "scrub sands," etc. The clay sub-soil is found at a depth of about nine feet, and, normally the depth of water is about eleven feet. The analytical results may be easily interpreted from what has been said in connection with similar soils in other counties.

Nos. 8 and 9 constitute a fair average of the good pine lands of Volusia. The principal growth upon it is tall, straight pine (about seventy per acre), with a few so-called "willow oaks." The undergrowth is wire grass, and partridge pea, with here and there, a growth of wild oats. The top soil was taken to a depth of eight inches. No further comments are deemed necessary. Sample Z was

VOLUSIA COUNTY SOILS.

Type of Soil.	"Grey Hammock"		"First-class Pine Land"		Orange Soil
	Soil	Sub-Soil	Soil	Sub-Soil	
Station Number	6	7	8	9	Z
Coarse Earth	1.30	38.40	3.20	2.80	....
Fine Earth	98.70	99.29	96.80	97.20	....
Humus	.10	.20	.42	.08	....
Nitrogen	.0308	.0224	.0266	.0294	.0890
Moisture at 100°C	.1180	.1860	.4060	.2500	1.2460
FINE EARTH.					
Insoluble Residue	98.5325	98.0720	96.3815	96.9420	96.0852
Potash (K_2O)	.0048	.0038	.0164	.0149	.0208
Soda (Na_2O)	.0728	.0749	.0790	.0762	.0088
Lime (CaO)	.0500	.0375	.0225	.0200	.0526
Magnesia (MgO)	.0297	.0171	.0279	.0351	.0145
Ferric Oxid (Fe_2O_3)	.2634	.3294	.3294	.3074	.2884
Alumina (Al_2O_3)	.0904	.4896	.8130	.8693	.8842
Phosphorus Pentoxid (P_2O_5)	.0112	.0160	.0577	.0608	.1660
Chlorin	trace	trace	trace	trace	trace
Sulphur Trixod (SO_3)	.0146	.0017	.0086	.0060	.0096
Carbon Dioxid (CO_2)	.0000	.0000	.0000	.0000	.0000
Water and Organic Matter	1.0640	1.1220	2.3560	1.3800	2.3910
Total	100.1334	100.1640	100.0920	99.7117	100.0101

analyzed by Prof. Robinson. The sample was collected by Mr. E. O. Painter, of DeLand. Mr. Painter designates this soil "Good Orange Soil." It is very similar in composition to the preceding sample, though it contains considerably more phosphoric acid and nitrogen. The writer is not aware whether this is a virgin soil, but is inclined to believe that it is not. It has probably been cultivated and fertilized liberally.

MARION COUNTY SOIL.

TYPE OF SOIL.		
Station Number	Soil 33	Sub-soil 34
Coarse Earth	13.20	7.50
Fine Earth	86.80	92.50
Humus	1.26	.51
Nitrogen	.0350	.0098
Moisture at 100°C	.8180	.3860
FINE EARTH.		
Insoluble matter	92.6315	96.5865
Potash (K_2O)	.0149	.0024
Soda (Na_2O)	.0352	.0655
Lime (CaO)	.1500	.0425
Magnesia (MgO)	.0198	.0162
Ferric oxid (Fe_2O_3)	.4262	.3487
Alumina (Al_2O_3)	1.6694	.9021
Phosphorus pentoxid (P_2O_5)	.2544	.1792
Chlorin	trace	trace
Sulphur trioxid (SO_3)	.0085	.0000
Carbon dioxid (CO_2)	.0000	.0000
Water and organic matter	5.0200	1.8080
Total	100.2299	99.9511

After repeated efforts, it was only found practicable to secure one sample of sandy soil from Marion County.

Nos. 33 and 34 include this sample. It was collected by Mr. W. C. Croom, of Reddick. Originally, the land was wooded with ash, hickory, oak, etc. The soil, proper, varies in depth from eight inches to one foot, while a clay stratum is reached at a depth varying from two and a half to three feet. This sample is well supplied with phosphoric acid and lime. It is most deficient in potash and next in nitrogen. Further comments are deemed unnecessary.

The following table affords a convenient and ready reference for ascertaining the amounts of insoluble matter, humus, nitrogen, potash, phosphoric acid and lime in the several soils included in the previous discussion. The table is self-explanatory and is hereto appended.

In the table the figures employed are the average of soil and sub-soil in each case.

The sample numbers employed are only those of the soils, the sub-soil numbers being omitted.

A better general average of the phosphoric acid and lime occurring in the sandy soils of that portion of the Florida peninsula included in this bulletin can be obtained by eliminating sample No. 1 (Lee County) and No. 44 (Polk County) in the case of the former, and samples No. 21 (Brevard County) and 1 (Lee County) in the case of the latter.

Such elimination will then make the total general average of all constituents in all soil samples analyzed as follows:

Insoluble residue................	96.0127
Humus	.63
Nitrogen..........................	.0409
Potash (K_2O)	.0094
Phosphoric acid (P_2O_5)	.0687
Lime (CaO)	.0564

Table showing the Total Average of Important Soil Ingredients in the Sandy Soils of the Central and Southern portions of the Florida peninsula and also showing the County Averages of those Ingredients in eleven counties.

County	No	Insoluble Residue	Humus	Nitrogen	Potash (K$_2$O)	Phosphoric Acid (P$_2$O$_5$)	Lime (CaO)
Brevard	12	97.5085	.24	.0378	.0086	.0336	.2100
“	13	98.2100	.21	.0252	.0111	.0192	.1075
“	21	87.5915	.39	.0434	.0588	.0608	4.8787
“	38	97.5710	.10	.0091	.0038	.0527	.0200
“	40	99.0485	.08	.0021	.0041	.0080	.0000
“	X	98.1951	....	.0261	.0198	.0333	.1150
		96.3541	**.20**	**.0239**	**.0177**	**.0346**	**.8885**
Dade	10	93.8197	2.51	.0364	.0574	.0280	.0200
“	14	93.4032	1.48	.0833	.0033	.0232	.0850
“	17	98.4256	.26	.0084	.0027	.0288	.3025
“	19	97.2740	.22	.0112	.0089	.0262	.0362
		95.7306	**1.10**	**.0348**	**.0181**	**.0245**	**.1109**
DeSoto	4	**97.4975**	**.40**	**.0497**	**.0106**	**.0080**	**.0537**
Hillsboro	75	91.4202	1.36	.0672	.0014	.3224	.1375
“	92	96.4472	.30	.0518	.0011	.1008	.1450
		93.9337	**.83**	**.0595**	**.0012**	**.2116**	**.1412**
Lee	1	82.4682	1.73	.2464	.0125	1.2815	3.3025
“	25	96.4305	1.37	.1162	.0058	.0208	.0000
“	26	96.2090	.80	.0714	.0000	.0496	.0725
“	28	97.3085	.93	.0630	.0125	.0112	.0000
“	59	97.4155	.63	.0350	.0055	.0064	.0350
		93.9663	**1.09**	**.1064**	**.0072**	**.2739**	**.6820**
Marion	33	**94.6090**	**.88**	**.0074**	**.0086**	**.2168**	**.0962**
Orange	31	96.4818	.45	.0294	.0000	.1027	.0137
“	60	98.2060	.25	.0028	.0034	.0792	.0000
“	62	98.8857	.14	.0014	.0106	.0224	.0000
“	Y	96.4261	....	.1100	.0160	.1175	.0624
		97.4999	**.28**	**.0359**	**.0075**	**.0804**	**.0190**
Osceola.........	47	97.4670	.67	.0266	.0038	.0056	.0112
“	49	97.7362	.70	.0252	.0037	.0088	.0075
“	51	96.6082	.87	.0434	.0000	.0384	.0300
		97.2704	**.74**	**0317**	**.0025**	**.0176**	**.0162**
Pasco	73	**94.9472**	**.97**	**.0406**	**.0024**	**.1360**	**.0850**
Polk.............	42	99.4830	.02	.0042	.0038	.0064	.0000
“	43	95.2190	.50	.0126	.0000	.2768	.0125
“	44	89.3950	1.15	.0294	.0000	2.4000	.1125
“	45	96.3590	.47	.0084	.0014	.2176	.0212
“	55	97.9165	.35	.0098	.0000	.0224	.0062
“	57	98.5205	.29	.0084	.0038	.0136	.0000
		96.1488	**.46**	**.0121**	**.0015**	**.4894**	**.0254**
Volusia	6	98.3022	.15	.0266	.0043	.0136	.0437
“	8	96.6618	.25	.0280	.0157	.0592	.0222
“	Z	96.0852	....	.0890	.0208	.1660	.0526
		97.0164	**.20**	**.0478**	**.0136**	**.0796**	**.0395**
Total average	......	**95.9876**	**.64**	**.0413**	**.0091**	**.1635**	**.2805**

Note—Analyses lettered X Y and Z in the above table were made by Prof. Norman Robinson, formerly State Chemist of Florida.

The figures in heavy type in the table are the county averages. The figures in heavy type opposite the total average represent the average of all soils included, independent of counties.

When the samples referred to above are omitted from the county averages in the counties in which they occur, the averages of such counties will then become:

Brevard Co.,	Lime......	.0905.		
Lee	" "	.0269.	Phosphoric acid,	.0220
Polk	" "	......	" "	.1074

Occurrence of Muck Deposits.

All over Florida there occur deposits of rich muck land of greater or less extent. In the peninsular portion of the State, especially, there are vast deposits which chemical analyses have shown to be of excellent quality. The principal muck lands of the peninsula extend from near the southern border of Orange County, southward, far into the Everglades. South of Lake Okeechobee, these lands have already been surveyed for a distance of more than fifty miles and found to be of a high character. Prior to 1882, little had been done towards reclaiming any of the vast muck area above mentioned, and it was generally regarded as of no value for agricultural purposes. Much of it was under water, the greater portion of the time, and all of it was too much saturated, all the while, to admit of cultivation. About fifteen years ago, Mr. Hamilton Disston, of Philadelphia, interested himself in these lands and inaugurated extensive plans for reclaiming large areas, situated principally in Osceola County, by means of drainage canals. As a result of the enterprise of that gentleman, several thousand acres of the muck lands of the above county have been reclaimed and are now successfully devoted to the culture of sugar-cane, rice, and to market gardening, etc. Several thousand additional acres have been drained and only await the additional essential preliminary treatment before being ready for profitable cultivation. Owing to the favorable topography of the country, Mr. Disston experienced no very great difficulty in accomplishing the drainage of the territory referred to above. All that was necessary was to construct canals of sufficient capacity, and these were constructed with comparative ease. As will be seen further on, to drain some of these rich muck areas will present a more difficult problem, and involve more expensive methods. Still, the drainage of the greater portion of these vast areas, is entirely feasible, and will be accomplished before very many years have elapsed.

The Lake Hart Muck Region.

The first area comprised in Mr. Disston's scheme of drainage, and which is now complete, is known as the Lake Hart region. Lake Hart it situated near the southern boundary of Orange County. This lake is on the watershed between the headwaters of the St. Johns and Kissimmee rivers. The Lake Hart region is drained by means of a canal northward into the St. Johns.

The Osceola Muck Deposits.

All of the muck area of Osceola yet drained, is situated in the northwestern part of the county, and is drained southward.

A few miles south of Lake Hart, near the northern border of Osceola county, is situated Lake East Tohopekaliga. This lake is connected by canal with Lake Tohopekaliga on the northern margin of which is located the town of Kissimmee. This lake has also been connected on its southern border by canal with Lake Cypress, lying south of it, and Lake Cypress, in turn, with Lake Kissimmee, still further south. The area described is already drained and much of it is now in successful cultivation. Immediately east of Lake East Tohopekaliga, begins another series of lakes, between which canals have either been completed, are in process of construction, or else, are projected. Beginning at the north this series comprises the following lakes:* Myrtle, Preston, Joel, Trout, Lost, Lizzie, Alligator, Mud and Gentry. The latter lake is also to be opened into Lake Cypress. When this series of lakes are connected, upward of fifty thousand acres of rich muck land will be reclaimed.

The Kissimmee River Muck Lands.

Another rich muck area is found along the Kissimmee river, which connects Lake Kissimmee with Lake Okeechobee. On an air line, the distance between these lakes is about eighty miles, but the winding course of the river makes the distance about one hundred and fifty miles. On both sides of the river occur rich muck deposits which gradually pass into the sand and pine lands lying back of them. Unfortunately, the drainage of the these lands is both a more difficult and expensive undertaking than was the case with the area previously described. Owing to their peculiar location, it is impossible to drain these lands by the ordinary canal system. This is due to the fact that the level of the river, even at low water, is almost the same as the level of the muck lands bordering it, while during the "rainy season" (i. e., from June until October) the river assumes the form of a lake, and spreads over wide areas. Under such circumstances the only practicable way to accomplish the drainage of the land would be to construct levees, such as are extensively used on the Mississippi river below New Orleans, along the Kissimmee, and employ pumps to remove the water. Such systems of drainage are now widely practiced in localities where the difficulties in the way of canal drainage are identical with those presented in this instance, and, as has been stated, it is only a question of a few years before this system of drainage will be practiced along the Kissimmee river.

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*Possibly the names of some of these lakes have been recently changed.

The Okeechobee Muck Deposits.

The next large muck deposits (probably the largest in the world) extend from the southern boundary of Lake Okeechobee, far into the Everglades. On the northern shores of this lake, there is very little muck, but nearer the southern border the deposit increases in width and depth until south of the lake they constitute those vast formations that form the northern border of the Everglades. The extent of this area is not known, but the muck formation occurs extensively in Osceola County, as well as in DeSoto, Dade, Lee, etc. To drain these lands would be a huge undertaking. Two methods have been proposed for accomplishing this result. One contemplates the drainage of Lake Okeechobee by cutting a canal from its southern border, southward through the muck deposits into the Everglades. Wiley (Agricultural Science, page 109) estimates that a canal which would answer all purposes during the rainy season would need to be about 300 feet wide and twelve feet deep. This would seem to be a more economical plan than constructing a canal to the Atlantic ocean from the eastern border of the lake. The length of a canal to the ocean would not be less than forty miles, and would pass through sand all the way. To cut a canal through this sand would, of course, be more expensive than cutting through the muck beds. Wiley estimates that a canal into the Everglades of the dimensions he proposes would permanently lower the water level of the lake six feet, which would be ample to render this vast tract of muck land available for agricultural pursuits.

The second plan for draining these lands is one which is already in operation. It contemplates the drainage of only a portion of the muck area on the southwestern border of Lake Okeechobee, embracing as yet, only the Hicpochee and Okeechobee sugar lands. Lake Hicpochee is about six miles distant from Lake Okeechobee, and a canal has already been constructed between them, Another canal, eighteen miles in length, has also been constructed from the former lake to another point on Lake Okeechobee. These, with a few minor exceptions, are the principal improvements that have thus far been inaugurated with a view to recovering this fertile territory and placing it at the disposal of the farming classes. The immense possibilities of this section of Florida cannot be conjectured, and when these vast areas are made ready to respond to scientific systems of cultivation, these great muck formations are sure to be prominent among the most fertile lands in the United States. Other muck areas of smaller dimensions occur throughout the peninsula, and analyses of a number of them are given in a subsequent table. It will be observed that many of them are of an exceedingly fertile character. Not only are they well supplied with nitrogen, but they also contain relatively large supplies of both phosphoric acid and lime. Only in potash do they appear to be seriously deficient. In the case of the large formations described at length above, it appears that only nitrogen is present in them in sufficient quantity. When the latter lands are cultivated, it will only be a short while before applications of phosphoric acid and potash will have to be made. Lime will need to be employed from the beginning. More along these lines will be said under the discussion of the separate analyses.

Origin of Muck Formations.

It is well known that muck formations occur in locations where organic matter is allowed to undergo slow decay. Hence, there is usually a tendency towards the accumulation of the material in marsh regions, or in shallow water. Here in Florida, the muck soils are usually found about the margins of lakes. Throughout the rainy season each year, the marshes bordering these lakes are partly covered with water, and always contain a luxuriant growth of vegetation. The vegetation is protected from fire by the water, and hence the accumulation of it is constantly increasing, and by the several natural agencies, is gradually compacted into a uniform mass. It is customary, locally, to divide the muck deposits of the state into two varieties, viz: saw-grass muck and bay-head muck. True, there are several intermediate varieties, but the above popular classification is sufficiently accurate for all purposes. It not only acquaints us with the origin of the deposits, but also with the conditions under which they were produced. The bay-head muck is formed in partially submerged swamps where the bay tree, or laurel, is plentiful, forming the most conspicuous growth, and where numerous other varieties of aquatic trees, shrubs, vines, reeds, grasses, ferns, and mosses abound. Vegetation of the above character has been constantly dying and accumulating under these conditions for indefinite ages, and has gradually been compacted into masses of vegetable mold, or muck. The saw-grass muck derives its name from the semi-aquatic, sedge-like grass of the same name, from whose decaying leaves and roots it is very largely formed. Robinson describes it as "a coarse, rank-growing, almost reed-like grass, possessing leaves which are stiffened by folding back upon themselves, and by means of their sharp, serrate edges are enabled to kill or crowd out other forms of vegetation and appropriate the land to its own growth." In its matured state, on account of its exceedingly coarse texture, it cannot serve either as pasture or forage Robbinson suggests that it, perhaps, might have, in pre-historic times, "proved a toothsome morsel" for the mammoth and the mastodon, "but," he adds, "the Florida steer, who considers wire-grass a delicacy, draws the line on this vegetable combination of knives, saws and daggers." He also asserts that it appears to him that saw-grass exists for the sole purpose of producing the richest muck in the world, for it is well known that deposits of the material of the saw-grass variety are usually more fertile than those included in the other division. It usually contains nearly twice as much of the costly element, nitrogen, as does stable manure, and where it is intelligently employed, the results from its use are always satisfactory. While the saw-grass variety is usually the richer, it must not be inferred that the bay-head muck is a valueless material. This latter muck possesses much agricultural merit. When the swamps, where it occurs, are drained, and placed in a suitable state for cultivation, they invariably make most excellent garden lands, and contain, relatively large supplies of nitrogen. Wiley (Agricultural Analysis, Vol. I, page 59) gives the following list of grasses, weeds, etc., as the principal growths now going to make up the large muck areas of Florida:

COMMON NAMES—	BOTANICAL NAMES—
Saw-grass.	Cladium effusum.
Yellow pond lily,	Nymphea flava.
Maiden cane grass.	Panicum curtisii.
Alligator Wampee.	Pontederia cordata.
Sedge.	Cyperus species.
Fern brake.	Osmunda species.
Mallow.	Malva species.
Broom sedge.	Andropogon species.
Arrow weed.	Sagittaria species.

The above list includes only the principal growths. It is not likely that the present growth upon the different muck areas includes all plants that have previously entered into the formation of the muck.

Conditions Influencing Muck Formation.

The changes which result in the transition of vegetation into muck are influenced very largely by temperature and, probably, to a less extent, by the presence of compounds of iron and sulphur. It is mainly the difference in temperature prevailing in the respective sections that accounts for the superior quality of Florida mucks over the principal deposits occurring in the northern states. In many northern muck beds, all the conditions are most favorable to the accumulation of deposits of excellent quality, save that of temperature. The vegetation from which the material is formed in northern climes, is fairly rich in nitrogen, and contains the salts of iron, sulphur, etc., but the resulting product is not so rich as the muck which is formed here. It is noticeable that the farther south the samples are taken for analysis, as a rule, the larger becomes the proportion of nitrogen in the deposits, and the more concentrated, so to speak, becomes the material. That the difference in temperature of the widely separated locations in which the formations occur has a great deal to do with the variable composition, cannot be doubted. Carbon dioxid and Marsh gas are produced very slowly below a temperature of 60 degrees F., and in northern latitudes, therefore, it is only during several months of the year that the process of sub-aqueous decay is at all rapid. In Florida, the temperature, a foot under water, seldom falls below 60 degrees F., and usually it is about 80 or 90 degrees, and under these conditions it is very likely

that the process of decomposition is quite rapid and well nigh continuous, and so it is that to this fact is largely due the presence in our midst of almost incalculable areas or muck lands of superior quality. In a recent paper, Robinson has contributed a very original theory to account for the influence of the salts of iron and sulphur in promoting the changes that occur in the transformation of vegetable matter into muck and by which its fertility is enhanced. In this connection he writes: "The key to these changes, to a certain extent, at least, is found in the abundant presence of iron and sulphur. The ferrous and ferric salts have played a triple role. First, they have acted their well-known part as oxygen-carriers—ferrous and ferric sulphate being reduced by organic matter to ferrous sulphid, and again, in turn, under the favorable conditions present, oxidized into sulphate; second, in conjunction with alumina, they have aided in fixing any volatile nitrogen compounds that may have been formed; and, third, they have been active gatherers of phosphoric acid and potash from solution in the surrounding water."

The superior physical character of Florida muck which gives to it a high value as an absorbent, etc., need not be discussed in this place. It is now in order to consider the separate analyses of the different muck samples reported in the table, which is subsequently inserted.

Referring to the table, sample No. 16 was sent from Dade County, and is a mixture of soil and sub-soil to a depth of three feet. It was forwarded by Mr. F. P. Wilson of Lemon City. The growth upon it is principally saw-grass, interspersed with maiden cane, thistles, lilies, etc. It appears to be seriously deficient only in potash. It is unusually rich both in nitrogen and lime, and is quite well supplied with phosphoric acid, and contains only a trace of chlorin. With proper preliminary treatment it will prove exceedingly productive.

Samples Nos. 53 and 54 are the soil and sub-soil, respectively, of a sample of reclaimed bay muck. They were forwarded by Mr. R. E. Rose of Kissimmee. The soil, proper, was taken to a depth of fourteen inches, and the sub-soil from fourteen to thirty inches, when a white sand formation, interspersed with clay, occurred. The growth upon it was bay, cypress, willow, maple, etc., and the soil proper, was much more thoroughly decomposed than the sub-soil, the latter being of a very fibrous character. It is rich in nitrogen, and contains a moderate supply both of phosphoric acid and lime. It is very deficient in potash, and the latter will doubtless have to be the first form of commercial fertilizer applied.

Samples Nos. 90 to 98, inclusive, were analyzed in the laboratory of the Department of Agriculture at Washington, D. C., under the supervision of Dr. H. W. Wiley, Chief Chemist. They are taken from Agricultural Science, page 119. Nos. 90, 91 and 92 were taken from the same spot, near the back of the muck land and bordering the pine forest, No. 90 was taken to a depth of one foot. No. 91 was taken immediately underneath No. 90, to a depth of two feet, and No. 92 beneath No. 91, to a depth of three feet. Each sample, therefore, represents a foot of depth, and the average of the three would represent the composition of the deposit to a depth of three feet, at which limit a sand formation was encountered.

Nos. 93, 94, 95 and 96 are samples taken from the front of the station ground, where the muck is deeper, in precisely the same manner as the three preceding samples. In the latter instance the sand formation was encountered at a depth slightly over four feet. The average of the four analyses in this instance would represent the composition of the muck bed to a depth of four feet.

Sample 97 was taken from the orchard of the St. Cloud plantation, four miles west of the station. The sample was taken only to the depth of usual tillage, in order to determine the effect of tillage on the composition of the muck. This land had been for five years in cultivation, chiefly in vegetables, but more recently in grape vines.

No. 98 was taken from a field that had been constantly devoted to the culture of sugar cane for five years. It, too, was taken only to the depth of tillage.

Nos. 90, 91 and 92 constitute a soil of a deep black color, and, when wet, it is very compact, and it is always retentive of moisture. Nos. 93, 94, 95 and 96 compose a soil of a brownish black color, and which is less compact and more easily drained. It will be noticed in the case of the first soil that the per cent. of organic matter decreases with each successive layer, there being only 13.35 per cent. of this material in the layer next to the sand. In the case of the second sample, hower, it will be noticed that the per cent. of organic matter is actually greater at depths of two and three feet than at the surface. As is usually the case, the percentage of nitrogen varies quite regularly with that of the volatile matter in both samples of the station soil. The actual form in which the nitrogen exists was not determined in the case of any sample reported in the table, but it is not likely that any considerable portion of it is present in the form of nitrates, since the natural condition of the mucks is not very favorable to nitrification. In those soils where lime is present in largest quantities it is likely that nitrification has progressed most rapidly, and where this substance is deficient in soils it will doubtless be the case that applications of it will materially increase the nitrifying process. It will be noticed that all analyses made at the Government Laboratory show the samples to be deficient in phosphoric acid, potash and lime. Especially noticeable is the absence of lime, and this and potash, doubtless, are the chief things needed in these soils. It will also be noticed that in the case of the cultivated soils the percentages of iron and alumina are very much higher. It is deemed unnecessary to further consider the analyses of the Osceola County mucks. All analyses of samples reported from this county, which were made under the supervision of Dr. Wiley, were taken from the vast tract of reclaimed Osceola muck land described in the preceding pages.

Sample No. 35 was forwarded by Mr. J. H. Tatum, of Bartow. It was collected to a depth of four feet about 725 feet south of Lake Hancock. Below this depth was encountered the usual sand formation. The growth upon it is bay, live oak, hickory, magnolia, and other hammock growth. The muck lands are nearly two feet lower than the water of Lake Hancock. On this account draining them will be somewhat expensive, but can readily be accomplished by a method applicable to such a case which is referred to in a previous place. The analysis shows the sample to be exceedingly rich in nitrogen and lime, and deficient in phosphoric acid and potash. These latter materials will be the first that it will be necessary to replenish when the soil is subjected to cultivation.

Samples R, S and T were analyzed by Prof. Norman Robinson, of Orlando. In the light of what has already been said it is deemed unnecessary to comment on them further than to remark upon their high contents of nitrogen and lime, and in the case of the two latter samples the relatively large per cent. of phosphoric acid. Only in potash do they appear to be noticeably deficient.

Samples Nos. 23 and 24 were forwarded from Lake County by Messrs. Tongue & Geiger, who reside at Killarney. No. 23 is popularly known as bay muck land

and No. 24 as saw-grass muck. The latter is reclaimed land from what was once the bottom of Lake Apopka. The growth upon the former is white bay, magnolia, sweet gum, ash, etc. The water level stands at a depth of about two and a half feet below the surface and it is, to all appearances, well drained. It would seem from the high per cent. of chlorin, however, that this is not the case. It is generally agreed that if chlorin occurs in as great a proportion as one part, per thousand of soil, it is injurious to vegetation. The sample is noticeably rich in phosphoric acid and lime, and contains a good supply of nitrogen, and is deficient only in potash. With the removal by drainage of the surplus salt (sodium chlorid) this land should be very fertile and, after the proper preliminary treatment, it ought to produce large yields. No. 24 also appears to be well drained, but it, too, contains a rather high per cent. of chlorin, though hardly enough to render its presence very detrimental. The sample is quite rich in nitrogen and lime, very deficient in potash and somewhat so in phosphoric acid. Its failure to produce in the past, if it has been properly fertilized and intelligently cultivated, is not apparent from the analysis.

This includes all samples of muck reported in the table, and it is hoped that the analyses and comments will prove of much value to those who are interested in the cultivation of muck lands. It is deemed advisable to insert just here a few brief suggestions in reference to cultivating muck lands, and the reader is asked to give them careful attention.

Some Hints on Cultivating Muck Lands.

It is popularly supposed that what are known as muck lands, some of which are covered with water throughout the greater portion of the year, are valueless for farming purposes. There could be no greater delusion. In many cases the excess of water does prevent their successful cultivation, but in nearly all cases this surplus water can be easily removed, and the land thus brought one step nearer the ideal state for cultivation. In all ordinary cases the removal can best be accomplished with either tile or open drains, and attention to drainage should always be the first step in the reclamation of these lands. If this matter is attended to, it is not likely that serious difficulty will be encountered in bringing them to a high state of fertility. In the event that they fail to produce satisfactorily after the drainage question has been settled, the defect may arise from one or two causes. Either they contain excessive amounts of some substances, such as proto-oxid of iron, which is known to be poisonous to plants, or else, the soil is deficient in some available form of plant-food. It sometimes happens, though rarely, that the former difficulty arises with soils. When the proto-oxid of iron does occur in excessive amounts, the fact can be easily detected by the unusually dark color of the soil, which also will straighten assume a reddish tinge when fresh portions of it are exposed to the air. Such exposure causes the lower oxid (proto-oxid) of iron to acquire an additional amount of oxygen, and become converted into the higher "sesquioxid" form which is entirely harmless to vegetation. Where this difficulty arises with a soil, it is easy to see that the remedy is very simple. It will only be necessary to thoroughly pulverize and work the soil from time to time so as to expose fresh portions to the air. In this way the chemical change noted above will proceed without difficulty. Often, frequent deep plowing and harrowing during a single season will suffice to bring about the desired change in this objectionable form of iron oxid. When this difficulty has been remedied, and the mechanical tilth of the land properly attended to, the failure of muck lands can usually be attributed to a deficiency of available plant-food. This deficiency will need to be supplied by applications of the proper fertilizers. These are the chief problems that confront the farmer who undertakes the reclamation of soils of this character, and by giving proper attention to the several points to which attention has been called, it ought to be an easy matter for him to bring all such lands into a profitable state for cultivation.

Plan of a set of plat Experiments by which the Farmer can ascertain the needs of his soil.

1	20 lbs. muriate of potash, containing 50 per cent. K_2O or, 20 lbs. sulphate of potash, containing 50 per cent. K_2O or, 80 lbs. Kainite. containing 12.5 per cent. K_2O.	
2	20 lbs. nitrate of soda, or, 40 lbs. tankage or dried blood, or 16 lbs. sulphate of ammonia, or, 45 lbs. bright cotton seed meal.	
3	20 lbs. muriate of potash (or the potash equivalent in sulphate, etc) 20 lbs. nitrate of soda (or its equivalent in tankage, C. S. meal, etc.)	
4	No fertilizer.	
5	40 lbs. acid phosphate, containing 14 per cent. available phos. acid.	
6	20 lbs. muriate of potash (or its equivalent in other forms mentioned.) 40 lbs. acid phosphate, 14 per cent. available.)	
7	20 lbs. nitrate of soda 20 lbs. muriate of potash 40 lbs. acid phosphate	or, an equivalent amount of any of the above fertilizing materials in each case.
8	20 lbs. nitrate of soda 40 lbs. acid phosphate	or, the equivalent of nitrogen in any of the above forms.

Size of the plats, one-tenth acre, (245x18ft). The same variety of crop must be grown upon each plat and care must be exercised to see that the seed employed are pure and that each plat receives the same quantity.

How to Conduct Field Experiments with Fertilizers.

Few questions are more frequently asked by the intelligent farmer than "What fertilizer does my soil require?" "Is it deficient in only one or two forms of plant-food, or is it deficient in each of the three that it is frequently necessary to apply?" Probably no Experiment Station has escaped these queries, and the same questions will, doubtless, be asked many times in the future. In asking these, farmers suppose that they can be readily answered simply by analyzing the soil. Unfortunately, however, as has been already stated, the methods of soil analysis have not been sufficiently perfected to furnish entirely accurate information upon this point. It has already been stated that a chemical analysis will show the total amount of plant-food present in a soil, but it will not, in the majority of cases, allow us to draw definite conclusions as to the exact quantity of this plant-food which occurs in a readily available form. The most satisfactory, and indeed the only method by which it is possible, at present, definitely to determine the needs of a soil, is to ask questions of the soil itself, by conducting practical experiments with a growing crop upon it, fertilized with different kinds of plant-food, and carefully noting the results. Such a soil test, when conducted in an intelligent manner, will be sure to yield results that will be of much practical value for the locality in which it is undertaken. Strange to say, it has been a difficult matter to induce farmers to take hold of such experiments with a view to ascertaining the needs of their soils. A majority of them seem to prefer to go on, refusing to fertilize at all, or else apply fertilizers indiscriminately and extravagantly, without regard to what the soil may actually need.

For some reason, farmers have looked upon such experiments as something too costly and too complicated for them to undertake, and consequently they have preferred to continue to use fertilizers in a reckless and haphazard manner, and at a great financial disadvantage. As a matter of fact, conducting such experiments, while, of course, demanding care, exactness and attention, is neither so difficult nor so expensive as many have supposed. To carry them on, in accordance with the plan hereinafter given, would only involve the use of eight small plots, and it need not necessarily continue for more than three years. It would seem that this would be a very small price to pay for knowledge which might save an unnecessary expenditure of large amounts of money for fertilizing ingredients which might be already present in the soil in sufficient quantity. No farmer, in these hard times, can afford to spend his money purchasing and applying fertilizing materials that may not be required. Experiments conducted as hereinafter described, will help any farmer to acquire an accurate knowledge of the needs of his soil, and with such knowledge, he will be able to buy and apply, intelligently, such fertilizing materials as practical tests will show his land to require. It is hoped that, at least, one intelligent farmer in every community, will study the plan that is given here closely, and see if it will not be wise for him to conduct an experiment upon his soil and learn exactly its condition as regards fertility.

For the convenience of any who may desire to inaugurate such experiments, the following directions are given in order that the results obtained may be entirely trustworthy. The selection of the field and of the experiment plats in the field, the size, shape and arrangement of these plats, the amount and variety of fertilizers applied, the cultivation and the method employed in recording observations, results, etc., are all important items and must be carefully looked after. Each of these points will now be carefully considered:

The selection of the field—The field selected for carrying out the experiments should be of uniform character, and should have received the same fertilizer treatment, and produced the same crop, at least the preceding year. If no fertilizer has ever been employed, it will do equally as well, provided the same crop has been grown upon it. Indeed, the poorer the soil, the more accurate are the results likely to be.

If possible, the field should be level, or, if this is not practicable, select a field with as uniform slope as possible.

It should also possess a good firm sub-soil, if such is to be had, and the under drainage should be, at least, fairly uniform. It may not always be possible to secure land answering all these conditions, but it should approximate as near as practicable all the points noted.

The Size, Shape and Arrangement of the Plats.

If the land selected is of uniform character, the plats can be smaller than where it is not uniform, and where the fertilizer employed in preceding years has not been identical over the whole strip.

The size of the plat will also be influenced by the character of the crop to be grown in the experiment. For instance, a larger plat would be preferable for a vineyard than for corn, cotton, oats, etc.

Long and narrow plats are preferred to square ones because frequently these are dissimilar strips included in the area selected, and if the plats are long and narrow, they all can be laid out so as to include this unlike strip and thus the results on all plats will be affected alike. If possible, the land selected should be laid out so that each plot shall extend across all unlike strips. A set of plats eighteen feet wide and two hundred and forty-five feet long will answer for most purposes in the case of ordinary field crops. Plats of these dimensions will allow four rows of corn, cotton, potatoes, or tobacco, etc., with four and-a-half feet between the rows. There would then be two inside rows on each plat to harvest for measuring the yield while the two outside rows in each case should be rejected. The area of a plat will be 1-10 acre, (i.e., "farmer's acre," which is generally understood to include 4900 square yards). Where small fruits are to be experimented with, results have shown that it is best to employ three rows to the plat and only employ the middle row in each case in recording results, the two outer rows being rejected.

Fertilizers employed—The variety of fertilizer employed will often times be determined by the circumstances, the cost, those most convenient, etc. For providing phosphoric acid, usually the best results will be obtained from acid phosphate, or where it is practicable to procure it, from dissolved boneblack. Here in Florida, it will be cheaper to employ the dissolved Florida rock (acid phosphate). The preceding plat diagram shows the quantity to be employed of a specific strength. If the grade of goods on hand is of an inferior strength, use a quantity of it equivalent in phosphoric acid to the quantity of the 14 per cent. material mentioned in the diagram.

In regard to potash, it is generally cheaper to employ muriate of potash for supplying this element of plant-food, but the precautions to be noted later relative to employing muriate should not be overlooked. In the case of certain crops, particularly tobacco, potatoes, beets and oranges, potash applied in the form of sulphate is desirable, and, I may say, necessary.

Kainite may take the place of muriate by employing four times the quantity of the latter, but it should not be substituted for sulphate, since, like muriate, it contains the objectionable element chlorin, which is known to seriously impair the quality of crops of the character above mentioned.

For supplying nitrogen, nitrate of soda and bright upland cotton-seed meal are the commercial materials most generally employed in Florida. They are among the cheapest, and the results obtained from their employment are universally satisfactory. Where nitrogen is to be applied as a top dressing, either in early spring or summer, the application is usually made in the form of nitrate of soda. But, if it is impracticable to employ this material, sulphate of ammonia, cotton-seed meal, dried blood or tankage may each be employed in supplying the necessary nitrogen. The equivalent amounts of each to be employed in the plats are shown in the previous plat diagram. In the event that dark cotton-seed meal is employed (i. e., meal made from long-staple sea island cotton), it will be necessary to use about one and three-fourths the amount recommended for the bright meal (decorticated). As to the quantity of fertilizer to be applied, per acre, it is generally better to employ liberal quantities, say 200 pounds of nitrate of soda, 160 pounds sulphate of ammonia, 450 pounds cotton-seed meal, or 400 pounds tankage or dried blood for supplying nitrogen.

For potash use 200 pounds, either of muriate or sulphate, or 800 pounds of kainite, etc.

For phosphoric acid, use 400 pounds acid phosphate of 14 per cent. grade, or an equivalent amount of an inferior grade.

The proportional parts of these several amounts are given in the preceding 1-10 acre plats given in the diagram. The cultivation of all plats should be the same. They should be fertilized and seeded the same day. They should likewise be plowed and hoed on the same day. After a rain the crust of all plats should be lightly stirred, in order to conserve the moisture. For recording results, a memorandum book should be at hand and frequent observations should be made and recorded of anything especially noticeable and unusual during all stages of growth. The appearance of any disease, or the uncommon appearance of the plants upon any plat should likewise be recorded. A record of the weather should also be kept. And, finally, when the harvest time arrives, the products obtained from the interior rows of each plat should be accurately weighed and entered upon the record book. If these directions are accurately observed, the results of the soil test experiments are, in the end, likely to prove satisfactory, and reasons for discrepancies between yields, due to causes other than fertilizers, will then more than likely be detected.

In measuring the crop due credit must be given for every part of it that possesses any value.

As will be seen, the diagram previously given shows the number of plats that it is necessary to employ in conducting fertilizer tests with soils, and the equivalent amounts of the several fertilizing materials to be applied. The plats are, each, one-tenth of the "farmer's acre" (44,100 square feet). In conclusion, it may be remarked that, in spite of the most scrupulous care, discrepancies of much consequence will frequently arise, and it will often prove exceedingly difficult to detect the real meaning of them; but where the experiments are continued through three seasons it is usually the case that satisfactory results will be obtained.

We shall be glad to advise with any individual who may contemplate undertaking such experiments. While it is not possible for us, at present, to bear any of the expense connected with the work, still we shall be pleased to furnish all necessary directions to any one who may desire to undertake such experiments. It is the writer's opinion that any farmer who will undertake the task will find himself richly repaid by the knowledge and experience he will gain as a result.

How to Employ Raw Materials in Mixing Fertilizers of a Specific Strength.

In preparing a definite quantity of a fertilizer mixture of any required strength care must be exercised in purchasing the raw materials employed in producing the mixture to see that they are sufficiently concentrated (i. e., each ingredient should be rich enough in the particular element of plant-food which it is to supply) to provide the definite quantity of it that will be required in the fertilizer mixture it is proposed to prepare, without allowing the total weight of the mixture to exceed the quantity desired. That is to say, if it is desired to make up exactly one ton (2,000 pounds) of a complete mixture that will analyze, say:

Phosphoric acid (available).....	6.00 per cent.
Potash..............................	10.00 per cent.
Nitrogen.........................	5.00 per cent.

It will be necessary to use the materials that are to be employed in supplying the several plant-food constituents in forms sufficiently concentrated to admit of the required amounts of phosphoric acid, potash and nitrogen being supplied while keeping the total weight of the raw material employed within the 2,000 pound limit; otherwise the fertilizer mixture, though containing the prescribed amounts of the several plant-food essentials, will not be of the percentage composition desired, but may be considerably less, depending, of course, upon the amount of excess over 2,000 pounds the total bulk may reach. Being careful always to observe this precaution, let it be supposed that we have on hand:

Acid phosphate containing 14 per cent. available phosphoric acid, sulphate of potash containing 50 per cent. of actual potash, nitrate of soda containing 16 per cent. of nitrogen, and desire to employ this raw material in preparing exactly a ton (2,000 pounds) of fertilizer mixture which will analyze:

Available phosphoric acid........	6.00	per cent.
Potash.................................	10.00	" "
Nitrogen..............................	5.00	" "

the first question to be asked would be: "How many pounds of phosphoric acid must the ton of fertilizer contain, if it is to analyze 6.00 per cent. of this substance? The answer to this would be, 120 lbs. (2,000 lbs. x .06= 120 lbs.) A similar query in regard to the number of pounds of potash and nitrogen that the ton of mixture is to contain will reveal the fact that 200 lbs. of the former and 100 lbs. of the latter must be present in every ton of mixture in order for it, when prepared, to be of the desired strength.

Having gained this information, the next question asked should be: How much acid phosphate of the strength designated above will it be necessary to use in order to supply the 120 lbs. of phosphoric acid that the proposed mixture is to have? To answer this, we revert to the analysis of the acid phosphate previously mentioned and find that it is guaranteed to contain 14 per cent. of available phosphoric acid. Then, we reason that if each 100 lbs. of the acid phosphate contains 14 lbs. of phosphoric acid, it will require as many hundred pounds to provide the 120 pounds of phosphoric acid the proposed mixture is to contain as 14 is contained times into 120, or, in other words, it will be necessary to employ 857 lbs. of the acid phosphate.

A similar course of reasoning, with a view to ascertaining the amounts of sulphate of potash and nitrate of soda that will be needed in supplying the requisite potash and nitrogen, will show that 400 lbs. of the sulphate of potash and 625 lbs. of nitrate of soda will have to be employed. We find, therefore, that in supplying the requisite phosphoric acid, potash and nitrogen, we have employed:

Acid phosphate	857	pounds.
Sulphate potash............	400	"
Nitrate soda	625	"

Making a total of 1882 pounds of mixture, when it was our desire to make 2000 pounds. These 1882 pounds, though, contain the exact number of pounds of phosphoric acid, potash and nitrogen that a ton (2000 pounds) of our proposed mixture was to have. Then, in order to increase the weight of the prepared fertilizer to exactly one ton, all that is necessary is to add to the 1882 pounds exactly 118 pounds of some cheap "filling," such as sand, which contains no appreciable amount of fertilizing material ($1882+118=2000$).

Now, in the ton of mixture, there will be present 120 pounds of available phosphoric acid, 200 pounds of potash and 100 pounds of nitrogen. When thoroughly mixed, it should analyze:

Available phosphoric acid........	6.00 per cent.
Potash..................................	10.00 per cent.
Nitrogen..............................	5.00 per cent.

With this explanation at hand, it should be an easy matter for every farmer to mix and prepare his fertilizers at home, of any desired strength, but the greatest care should invariably be exercised to insure thorough mixing. Where it can be properly done, it will be found far more economical for farmers to purchase the raw materials, unmixed, and do their own mixing. Of course, where mixed, fertilizers are to be employed for home use, the addition of the sand "filling" will not be necessary. In such a case, it will only be necessary to apply an amount of concentrated mixture equivalent in fertilizing value to what would have been applied had it been made up to exactly 2000 pounds. But in every case where a definite quantity of a mixture of a specific strength is to be prepared, the method described above is always employed in the process of preparation.

This plan also has the additional advantage of allowing the farmer to prepare complete fertilizers of varying strengths and which are especially adapted to particular soils and crops.

Some Instructions in Using Lime.

When soils are of an acid character, such crops as clover, alfalfa, and certain other leguminous plants which under proper soil conditions, have the power to utilize the nitrogen of the air existing in the soil, are unable to make a satisfactory growth. Moderate applications of water-slaked lime under such circumstances will prove highly beneficial in sweetening such soils and promoting nitrification. Often, injury results from the application of lime in a caustic state. When applied in this form, particular care must be exercised to avoid excessive applications, even on soils where crops requiring a relatively large lime nourishment are to be grown. Next to the water-slaked, air-slaked lime is the most satisfactory form in which to make lime applications. On thin, sandy soils deficient in lime, from 500 to 1,000 pounds, per acre, is the proper quantity to apply. On heavy soils these quantities should be increased about one half. It is generally best to make lime applications sometime in advance of planting. Autumn applications are generally to be preferred. It should be distributed with great uniformity and carefully plowed and harrowed into the soil, otherwise its beneficial effects will be greatly retarded. On soils needing this material, about every four years would be the proper interval for administering lime dressings to soils. Lime should, immediately after being applied, be harrowed into the soil, otherwise it will likely cake, and this would detract from its good effects.

Lime Promotes the Growth of the Potato Scab Fungus.

Unfortunately, it has been found that lime is conducive to the growth of the potato scab fungus. Hence, when it is applied to soils to be employed in cultivating this tuber, either separately or in a crop rotation, it should be applied in very moderate quantities. Before planting, the seed-tubers should also receive some germicide treatment, either corrosive sublimate, formalin, or other appropriate one. Corrosive sublimate is very generally used with good effect. It is intensely poisonous and should be handled very cautiously. Discarded solutions of it should not be thrown out around the premises in reach of fowls or to find its way into the well. Corrosively sublima can be easily procured in the form of small white crystals at any drug store. To prepare a germicide solution of it of proper strength, dissolve two and one-fourth ounces of these crystals in several gallons of hot water in a suitable barrel, and subsequently make the solution up to fifteen gallons by the addition of cold water and stir thoroughly. The same solution may be used over and over again, but should be kept carefully covered to prevent access to it by fowls, etc.

The seed-tubers after being washed, and without being cut, may be placed in a sack and immersed for an hour and a half in the solution. They will be uninjured for planting by this treatment, while their susceptibility to this fungus attack will be very greatly diminished. A solution of the above strength will not injure the hands but it should not be allowed to enter the mouth under any circumstances.

Harmful Effects of Continual Use of Muriate of Potash.

Among the different sources for obtaining potash for fertilizers, muriate of potash is most common. This is partly because it contains potash in concentrated form, averaging about fifty per cent., and also, because, as muriate, the material can be purchased somewhat cheaper. A reason for the latter is found in the fact that, on account of chlorin being one of the constituents of muriate, upon certain crops, such as tobacco, potatoes, sugar-beets, etc., it is known to exert an unfavorable influence upon their quality. On account of its cheapness, where it will exercise no deleterious effects on either the soil or crop, it will, of course, be desirable to employ the muriate as the source of potash, but under the conditions above noted, as well as under certain others now to be mentioned, the potash supply should be provided in other forms.

It has recently been observed by Prof. Goessmann of the Massachusetts Station that upon soils having compact sub-soils, and upon those which are not well drained, and in which the supply of lime is small, the continued application of muriate of potash may prove quite injurious. Under such conditions as are noted above, a chemical change occurs between the lime of the soil and the muriate, whereby the chlorin of the latter unites with the soil lime, forming calcium chlorid, an objectionable compound possessing poisonous properties to plants. Fortunately, this compound is easily soluble, and if the land is well drained it will readily pass from it, but, under the conditions noted above, its presence might prove highly injurious. Goessmann observed that such crops as oats, soja beans, etc., grown upon a soil which had received a continued application of muriate of potash for a number of years continued to decrease in yield year after year, and finally he became convinced, by experiment, that this decrease was due to the effect of the muriate of potash on the lime of the soil A part of the chemical change referred to above is, that the potash is, in turn, converted into a less soluble form, which really is desirable, because less of this material is then likely to be lost by leaching; but it should be remembered that this change always occurs at the expense of the lime. If the supply of lime is abundant in a soil no serious results are likely to follow from the use of muriate in a favorable season, but, under the circumstances noted above, its use may prove injurious.

The employment of the muriate is safer upon a deep soil with open sub-soil, because in a soil of this character the poisonous lime compound formed passes readily out of the reach of the plant.

In all cases where the continued use of muriate would prove objectionable, sulphate of potash may be substituted in its stead, and the objections above noted will not apply to this material.

How to Ascertain if Soils are of an Acid Character.

It is a very easy matter to ascertain whether or not a soil possesses acid properties. Soils that contain much carbonate of lime are of an alkaline character, (i. e., directly opposite to acid). Such soils, of course, need no liming. But when a soil is distinctly acid, as is often the case, particularly with muck soils, additions of lime are always desirable. In order to determine acidity, a very simple test will suffice. Employ a narrow strip of blue litmus paper, an inch and a half in length, (to be had for a trifle at any apothecary shop) in conducting the test. A few ounces of the suspected soil may be placed in a glass and made into paste with water by stirring with a rod or stick. Allow the paste to stand for a half hour, and then with a knife blade separate the paste, and insert the strip of litmus paper and press the moist soil against it with the blade, and allow the paper to remain in this position for about five minutes. Remove the paper and see if the end placed in the soil has changed from the original blue color to red. If such a change has occurred, it proves that the soil is acid, and that an application of lime will usually prove beneficial. The end of the paper to be inserted in the soil should not be handled because often such handling will produce a red coloration of the litmus, and without proper precaution is excercised, this change might be ascribed to the soil. See that the end of the paper applied to the soil is distinctly blue when inserted. Blue litmus will invariably be changed to red by acid soils, and red litmus to blue by distinctly alkaline soils. Faintly alkaline soils will be neutral to test paper.

Acknowledgment.

Before concluding this bulletin, I must not neglect to express my gratitude to General Superintendent Dunham, of the Plant System, and General Manager Maxwell, of the Florida Central and Peninsular Railway Company, to both of whom I am greatly indebted for valuable assistance in securing soil samples for analysis. Not only did these gentlemen have a majority of the samples reported upon in this publication collected in accordance with the instructions issued from this laboratory, but, prompted by a generous and helpful spirit, they transported all samples from the points whence they were taken to the laboratory at Lake City without cost. But for their valuable assistance in collecting samples, it is doubtful if this bulletin could have been issued.

AVERAGE COMPOSITION OF THE VARIOUS FERTILIZING MATERIALS (COMMERCIAL AND DOMESTIC) USUALLY EMPLOYED ON SOUTHERN FARMS.

Essentially Nitrogenous Fertilizers.	Per cent. Nitrogen	Per cent. Ammonia Equivalent	Per cent. Potash	Per cent. Available Phos. Acid	Per cent. Total Phos. Acid	Per cent. Insoluble Phos. Acid
Nitrate of soda	15.75	19.00	....	....	....	....
Sulphate of ammonia	20.50	24.80	....	....	....	....
Cotton seed meal (decorticated)	6.66	8.05	1.80	3.00	....	....
Cotton seed meal (undecorticated)	4.50	5.44	1.50	3.00	....	....
Linseed meal (old process)	5.43	6.57	1.37	1.66	....	....
Linseed meal (new process	5.78	6.98	1.39	1.83	....	....
Dried blood	10.52	12.72	....	....	1.91	....
Dried fish scrap	7.25	8.77	....	7.00	....	....
Muck (good)	1.10	1.33	.15	....	.10	....
Barnyard manure (69 per cent. moisture)	0.49	0.59	0.43	....	0.32	....
Horn and hoof waste	13.25	16.03	....	....	1.83	....
Wool waste	6.50	7.86	1.20	....	0.35	....
Wool washings	....	....	3.92	....	....	....
Poudrette (night soil) (50 per cent. moisture)	.80	.96	.30	....	1.40	....
Bat guano	8.20	9.92	1.31	....	3.80	....
Pigeon manure (10 per cent. moisture)	3.20	3.87	1.00	....	1.90	....
Essentially Potash Fertilizers.						
Muriate of potash	....	....	51.50	....	....	....
Sulphate of potash	....	....	50.00	....	....	....
Sulphate of potash and magnesia	....	....	26.00	....	....	....
Kainite	....	....	12.50	....	....	....
Cotton hull ashes	....	....	22.75	....	8.85	....
Saw palmetto ashes (as ordinarily burnt)	....	....	15.00	....	10.00	....
Wood ashes (unleached)	....	....	5.25	....	1.70	....
Wood ashes (leached)	....	....	1.27	....	1.51	....
Tobacco stalks	3.71	4.49	5.02	....	0.65	....
Tobacco stems	2.35	2.84	8.20	....	0.70	....
Corn-cob ashes	....	....	23.20	....	6.00	....
Essentially Phos. Fertilizers.						
Acid phosphate (dissolved rock)	....	....	....	10.15	....	....
Bone ash	....	....	....	....	35.89	....
Bone black	....	....	....	....	28.28	....
Bone black (dissolved)	....	....	....	16.70	17.00	....
Bone meal	4.05	4.90	....	8.00	23.25	....
Bone meal (glue factory)	1.70	2.05	....	....	29.90	....
Bone meal (dissolved)	2.60	3.14	....	13.53	17.60	....
Thomas slag	....	....	....	3.06	23.49	....
Florida rock	....	....	....	....	25.35	....
Florida soft phosphate	....	....	....	....	18.20	....
South Carolina rock	....	....	....	....	25.30	....
Tankage	6.70	8.10	....	....	11.80	....
Peruvian guano	7.35	8.89	2.65	7.30	15.30	....
Cuban guano	1.67	2.02	....	....	13.35	....

COMPOSITION, AMOUNT AND VALUE OF MANURE PRODUCED BY DIFFERENT KINDS OF FARM ANIMALS.

The following table comprises results of experiments conducted at the Cornell (N. Y.) Experiment Station, and are taken from Agricultural Calendar for 1896 (Woll).

	Analysis and Value, per ton, of Manure.					Amount and Value per 1000 lbs. Live Weight per day.		
	Water	Nitrogen	Phosphoric Acid	Potash	* Value Per ton	Pounds Per day	* Value Per day	* Value Per year
	Per cent	Per cent	Per cent	Per cent	$		Cents	$
Sheep	59.52	.77	.39	.59	3.30	34.1	7.2	26.09
Calves	77.73	.50	.17	.53	2.18	67.8	6.7	24.45
Pigs	74.13	.84	.39	.32	3.29	83.6	16.7	60.88
Cows	75.25	.43	.29	.44	2.03	74.1	8.0	29.27
Horses	48.69	.49	.26	.48	2.21	48.8	7.6	27.74

*Valuing nitrogen at 15 cents, phosphoric acid at 6 cents, and potash at 4.5 cents.

What the Tables Teach.

With what has been said it ought to be an easy matter for every farmer who studies these pages closely to understand the real fertilizing value of any substance incorporated in either of the foregoing tables. Such knowledge ought to enable him better to understand how to proceed to fertilize his soil, using only such material for the purpose as will be sure to subserve the desired ends. When phosphoric acid is what is needed, then any material enumerated in the foregoing list of phosphatic manures may be counted on to supply the deficiency, and the same may be said in regard to potash and nitrogen. Where one substance contains an appreciable quantity of both potash and nitrogen (such for instance, as nitrate of potash and tobacco stems), the table will show it. Further comment is deemed unnecessary.

Bulletin 44 January 1898.

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FACTS.

1 The Soil and Climate of Florida are Better Adapted to the Successful Production of Sugar-cane and its Products than is any other part of the United States.

2 Nitrogen is the Chief Manurial requirement of the Cane Crop. Planting on Bottom Lands, Turning Under of Cow-peas or of Velvet-beans, and "Cow-penning," are the most economical means for securing this essential. On Florida Soils, Potash stands next to Nitrogen as a food requirement for Cane.

3 Narrow Rows and two lines of Seed Cane are the desirable forms for Planting.

4 Thorough Breaking and Shallow Cultivation, with Cultivator instead of Plow, produce best results.

5 The Longest Possible Period of Growth should be allowed. Delaying Harvest ten days from Nov. 20 increased the Sugar content 1.2 per cent., and twenty days delay adds 4.39 per cent. to the amount of Sugar in the Cane.

6 Great Variations in the Thickness of Syrup injure its market value. When the Thickness is determined by Judgment or Experience variations of 5 degrees are possible by the most Expert Syrup Boilers.

7 A Simple Syrup Tester may be made, by any one without expense, which Determines the Thickness with Absolute Accuracy and Prevents the Possibility of Variation.

8 Red Cane is Hardier than Green and Matures Earlier. For Large Areas and for Sugar the Red Variety is best. For Small Areas and Syrup the Green Cane is preferable.

9 Uplands Produce the Sweetest Cane. Bottom Lands Produce the Heaviest Yields and the Largest Total Product.

10 The Impurities in Cane Juice are chiefly Physical and may be Removed by thorough Straining or Filtering.

11 Dry Spanish Moss is the Best Known Filter for Cane Juice, and its Use results in Superior and Well-Keeping Syrup, and Light Colored Dry Sugar.

12 Two Evaporators, Pans or Kettles are desirable. The First for Purifying, the Second for Finishing.

13 Syrup of Superior Appearance and Flavor can be made to Keep Indefinitely.

14 Good Domestic Sugar may be Made by Simple Home Means, and is Marketable at a Profit.

INTRODUCTION.

The author of this Bulletin, on entering upon his duties at this Station last October, found two acres of sugar cane grown as a regular farm crop without apparent experimental object, but chiefly as a means of utilizing land well adapted to the requirements of the cane plant. It was immediately decided to use this crop in the interest of the public as a means of demonstrating the possibility of improving the methods heretofore in practice for utilizing the same. It was too late to secure experimental data bearing upon the care and cultivation of the growing crop, and therefore the portion of the Bulletin devoted to a consideration of these conditions is based upon successful practice elsewhere and the personal experience of the writer on his own plantation rather than with the cane grown by the Station.

The growth of cane for the manufacture of sugar and syrup is no new enterprise in the State of Florida where soil and climatic conditions have, since the Spanish settlement, been recognized as admirably adapted to this business. Before the war there were large and flourishing sugar plantations in several different portions of the State, though of recent years the introduction of new industries and radical changes in social and business conditions have wellnigh exterminated the industry except as a very general means for supplying home demand It is believed, after a thorough investigation of the conditions involved, that climate, soil and economical advantages should naturally make Florida the great center of cane sugar production for our country. This Bulletin, however, is not written and the experiments on which it is founded were not undertaken in an effort toward demonstrating these facts. The object in view was the hope of showing that the production of sugar-cane offered a certain source of remuneration to farmers who would engage in the same. That the manufacture of syrup, when properly conducted, resulted in a product for which there was a ready and constant demand. Further, that every farmer in Florida might produce sugar sufficient for home consumption and of such a quality that the surplus could be readily and profitably marketed, and that the producer must necessarily become independent and reasonably free from all possible exactions imposed by any monoply controlling this domestic necessity. In other words, this Bulletin is an effort toward inculcating the principle and showing the possibilities of the production of home supplies for home consumption.

I.

THE CROP.

Sugar cane is more restricted in habitat by climatic conditions than is the case with most farm crops. Of East Indian origin, it can be made to thrive only in tropical or semi-tropical latitudes, and the two predominating essentials of its growth are warmth and moisture. Its successful cultivation, however widely distributed over the earth, has never been carried beyond certain well-defined limits of variation. A mean average temperature of 70 degrees and a minimum annual rainfall of about 60 inches are essential to the normal development and satisfactory cultivation of the crop. Both of these requisites are furnished by nearly all parts of the Florida peninsula. The mean annual rainfall for the latitude of Lake City is 55.86 inches, and the mean annual temperature is 68.78°.

As Louisiana is recognized as the chief sugar-producing State of the Union, it is interesting and important that a comparison of the climatic conditions prevailing there be made with those belonging to our own State. This comparison shows that our average annual rainfall exceeds that of Louisiana, that our mean temperature is higher, and that the period of immunity from frosts is longer. It is, moreover, an accepted fact that ideal weather conditions for cane development demand that about 75 per cent of the total rainfall should be during the growing season. This ideal rainfall is 45 inches. It is interesting to note that the rainfall of Louisiana for this period averages 54.74 inches, while that in Florida is 43.58. The adaptation of the climate of Florida to the normal development, and therefore successful production of the crop, is established.

SOIL CONDITIONS—As might be inferred from the origin of the plant, abundance of moisture and of organic matter are essential conditions in all soils upon which sugar-cane is to be successfully grown. Alluvial bottom lands and muck soils are pre-eminently adapted to the requirements of the crop. It must be particularly specified, however, that wherever muck soils or bottom lands are utilized for cane growing, thorough drainage is an absolute and indispensable prerequisite to success, since although large quantities of water are needed by so rank-growing and foliaceous a plant, excess of moisture at its roots is almost certain destruction. There are pine and high hammock lands in our State which, though producing lighter yields of cane possess a material advantage for its production. The cane of the pine lands is higher in its sugar content, and also possesses greater immunity from frost.

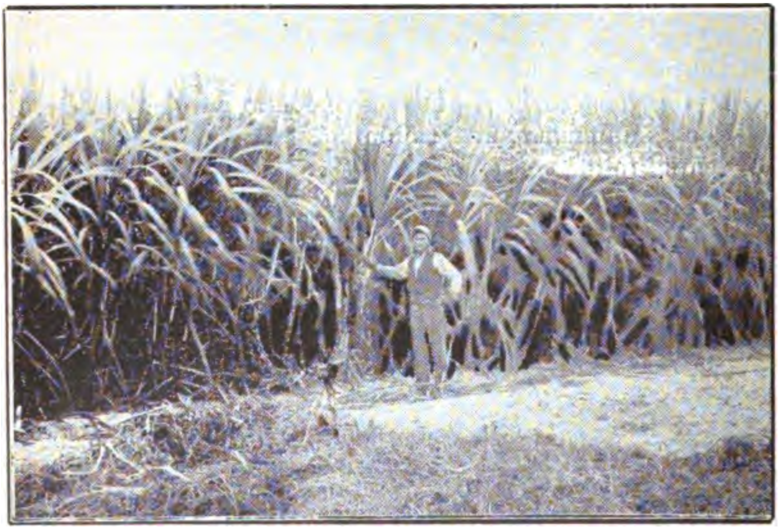

Fig 1.

PREPARATION OF THE LAND—The first essential toward proper preparation of the land for the growing of cane is thorough breaking or plowing to the depth of the arable soil, and this is true irrespective of the character of the soil in question. The manner of plowing, however, must vary with the nature of the land, which fact is also true as to the time of plowing. Bottom lands should be plowed as soon as possible after the crop has been removed in the fall that the action of the atmosphere upon the soil for the longest possible period may be secured. Lighter upland soils, however, need not necessarily be plowed until the time approaches for actually putting in the crop. Heavier and moister soils must be plowed with particular reference to winter drainage, which is best secured by throwing the soil into beds about six feet wide, the middles of which should be broken out with a turn plow and the quarter drains cleared sufficiently deep to assure drainage for the surplus water. With upland soils this precaution is not necessary, but simple plowing with a turn plow to the depth of the arable soil is all that is needed. The next consideration previous to actual planting of the cane is that of supplying the plant food necessary for its growth.

FERTILIZING THE CROP—Cane is a particularly rank-growing plant, and demands liberal feeding for the most satisfactory results. Comparisons of the composition of cane grown upon upland and bottom soils, however, abundantly demonstrate that the unquestioned adaptation of the crop to lower lands results as much from the necessity of abundant water supply for this foliaceous crop as upon the demands of the same for any particular form or quantity of nutriment. Indeed, the very best results in cane growing have been secured on upland soils where the demands for moisture were artificially supplied by irrigation. Observation of the conditions under which cane best thrives, supported by practical experience in all successful cane-growing countries and by the experiments conducted upon the plant-food requirements of this crop, demonstrate that nitrogen, preferably from organic sources, is the predominating, or chief, plant-food requirement to be considered in artificially fertilizing sugar-cane. The success of the common practice of "cow-penning" for this crop upon the light Florida soils and of turning under heavy crops of cow-peas upon the cane lands of Louisiana give indisputable evidence of the truth of this assertion. The most satisfactory results of sugar-cane culture, however, demand attention to the other two plant-food ingredients, phosphoric acid and potash, the latter particularly having a material influence and beneficial effect upon the sugar content of cane. If artificial fertilizers, therefore, are to be used they should provide the three essentials—phosphoric acid, nitrogen and potash—and experience shows that the relative proportions of supply under average normal conditions should be approximately one part of phosphoric acid to three parts of nitrogen and two parts of potash. The quantity of the application must depend upon the fertility or previous crop of the soil, and if leguminous crops have been grown and turned under on the same, one-half of the nitrogen may be omitted from older lands, while newer soils would probably require no other nitrogen than the turning under of good crops of cowpeas or velvet beans. The time for applying fertilizers must necessarily depend upon locality. Much sugar-cane, particularly in the State of Louisiana, is planted in the fall, in which event a part of the fertilizer may advantageously be applied at that time. Under prevailing Florida conditions the bulk of the crop is, and doubtless should be, planted in the spring.

Acid phosphate, cottonseed meal and muriate of potash are the most economical and effective forms of supply of plant-food for cane, and these materials are best applied immediately preceding actual planting of the cane. The best method of application is strewing in the furrow and mixing with the soil with a single trip of a scooter, by which means the fertilizer will be near enough to the seed cane to supply the immediate demands of the young plant, and yet will be sufficiently diluted by incorporation with the furrow soil to avoid the danger of killing the buds or tender rootlets.

PLANTING CANE—As a rule, February and March may be accepted as the cane planting months for our State. The variety of cane which shall be selected is also open to little question, experience having abundantly demonstrated that of the many varieties tested, red cane, from its sweetness and hardiness, stands incontestably at the front, though for syrup making the softer and less hardy green cane is not without advocates, while for the purpose to which all children and many adults naturally prefer to devote the plant, its softness and the ease of mastication give it first place. The distance of planting is an all-important consideration which experience and experiment have proved is of vital significance in controlling results. The general principle may be stated that the nearer the rows the greater the yield. The cost of seed, however, is a modifying influence which would effectually control practice. Narrowing the rows beyond the five-feet limit does not compensate in additional yield for the expense of the increase of seed. It may be accepted, therefore, that the most profitable distance for cane rows is five to six feet, the former distance having preference. The amount of seed cane which shall be used is likewise of material influence upon the economy of practice, one row, two rows, and three rows of seed canes in the furrow each having advocates. Two rows of seed cane, laid parallel and without intervals between their ends, may be accepted as productive of best results upon moderately fertile soils. The canes for planting should not be tipped but should be used as long as possible without being cut except where their crooked character necessitates cutting to facilitate covering with a plow and continuity of row.

In this connection it is well to recall the fact that the upper third of the cane stalk, which is least desirable for either sugar or syrup, is really the best part of the cane for seed, and might, with advantage, be saved for this purpose. A shovel plow, turning a furrow four to five inches deep, is the best means of preparation for the seed cane which, when laid in the furrow, is easily covered with a double trip of the turn plow.

Though stubble cane may be used for seed, the result is so inferior that the practice should only be a last resort in event of accident or dearth of supply of seed cane.

CULTIVATION—The depth and frequency of cultivation will largely control results. To effect the desired end, the plow should be rigorously discarded and be exclusively supplemented by the use of some form of tooth cultivator. Two advantages are secured by this change in implement; economy through the increased area which can be worked by a single implement and conserving moisture at the time it is indispensable to the proper development of the crop. The two-horse cultivator is preferable where large areas are involved, though the one-horse implement will easily and thoroughly work five acres of cane per day, which is fully double the amount possible from the most successful use of plows. When the marked difference in the amount of available moisture secured to the crop by the two methods of cultivation is considered, the experience of Dr. Stubbs, of the Louisiana Station, on which he bases the assertion "that it is almost impossible to estimate correctly the annual damage to the cane crop of this State by the use of turn plows in its cultivation" seems entirely reasonable. The frequency of cultivation must depend upon the season. The rule, however, should be to keep the surface soil thoroughly pulverized and friable and cultivate as often as it becomes compacted at the surface.

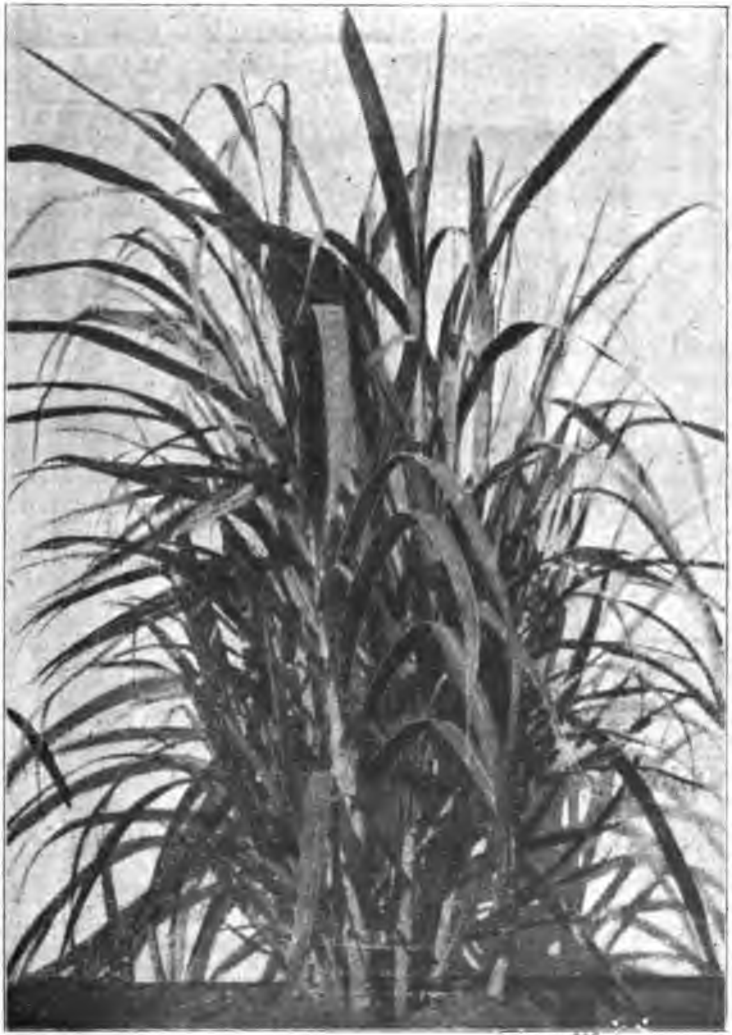

Fig. 2.

CANE AT TIME OF LAYING BY.

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In June or July the suckering should be finished and the growth so far advanced and the ground so shaded that further cultivation is unnecessary and the crop may be laid by.

HARVESTING—On small plantations, or with small areas, which is the condition which this Bulletin is chiefly intended to meet, the actual harvesting of the crop should be preceded by stripping the stalks some two weeks before grinding is to begin. This practice has two advantages. First, ripening of the cane and consequent storing up of sugar is furthered. Second, as the leaves must inevitably be removed before the cane can be ground, by performing the labor at this time economy is effected by reducing the amount of labor actually required at the time of harvest. It is even problematical if this practice would not be best under all circumstances, though on large plantations stripping of the cane is performed by means of the cane knife at the time the stalk is actually cut.

THE PRESERVATION OF SEED CANE.—For the Spring planting advised seed cane must be kept over Winter. This may be easily done by throwing two or more rows together on the ground so that the foliage of one plant covers the stalk of the other and protects it. The earth is then turned toward the row on both sides by a plow and the covering completed by hoe. Care must be taken to provide for drainage, and on wet soils the seed cane is best removed to the dryest available place. The green tips too low in sweetness for other use make superior seed and should be preserved for the purpose.

EFFECT OF TIME OF HARVEST UPON YIELD OF SUGAR.—We come now to the considera-

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* (Sugar Cane, vol. I, page 154)

tion of a most important point, indeed one on which the entire success of cane growing may not infrequently depend. It is a universally recognized fact that the longer the period of growth, or time during which the cane may be allowed to stand in the field, that is, up to the time of actual freezing weather which shall convert sucrose into glucose, the better. In this connection, therefore, it is well to suggest that the cane need not necessarily be taken to the mill and crushed at the time of cutting, but that it may be allowed to remain standing as long as serious danger from frost will permit and then be cut and wind-rowed in the same way that seed cane is preserved, in which condition it may be kept intact and uninjured long after frost occurs and from the wind-row be removed to the mill and worked up at leisure.

As bearing upon the point of the effect of longer standing and continued ripening upon the sugar content, an experiment was made with three varieties of cane at hand, stalks being cut and polarized for sugar at ten-day intervals with the following results:

	Nov. 20.	Nov. 30.	Dec. 10.
Red cane	14.22	15.34	15.60
Green cane	10.10	11.41	15.15
Ribbon cane		10.34	12.36

Comparison of these figures shows that an increase of ten days in the period of growth is followed by an increase of 1.2 per cent, and an increase of twenty days in the period of growth results in an average increase of 4.39 per cent in sugar content—the difference between a possible losing crop and an extremely profitable one, so that the inevitable conclusion is that with the precautions against frosts suggested, cane should be left standing, growing and ripening as long as possible, and that, for our latitude, December 10 is a reasonably safe and the most profitable time for beginning the harvest.

Not only is this fact of vital importance as controlling our own practice, but it sheds great light upon the question of the relative adaptation of our State to the successful and profitable production of sugar-cane as compared with the prevailing conditions in Louisiana, the recognized sugar-producing center of the country. In that State conditions are such that most sugar planters actually begin harvesting their crop in October, while Dr. Stubbs, in a laudable endeavor to extend the period of ripening and thus increase the sugar yield, advises that "Nov. 1st would seem from experience to be the best time to begin the harvest."* There would seem, however, to be no question that a period of growth, five to six weeks longer than that advised for Louisiana, is available to the cane grower of Florida, even in the latitude of Lake City and Jacksonville, which localities, however, are far north of the actual center of probable profitable cane production in Florida. In further support of this assertion I refer to the weather statistics covering a period of ten years of observation at the Louisiana Sugar Experiment Station, whereby it appears that during five years, of the ten included, injurious frosts have appeared there during the month of November, while the records of the United States Weather Service Station at Jacksonville, covering a period of twenty years, show no occurrence of killing frosts during this month, the average lowest temperature of which, for this period, is 54.1 degrees. †

When it is further remembered that the data for Louisiana are from the State Sugar Experiment Station, the location of which is in the very center and presumably the most favored portion of the State for cane development, while those for Florida are from Jacksonville, a locality on the very northern confines of the cane-producing portion of Florida and more than 100 miles north of the real cane area of the State, south of which there is an enormous extent of cane lands below the 28th parallel and recognized as practically below the frost line, there can be no question that Florida possesses advantages for cane growing and sugar producing possessed by no other State in the Union.

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* Sugar Cane, page 159.

† The average date of the first frost at Jacksonville is Dec. 4.

II.

SYRUP.

THE REQUIREMENTS OF GOOD SYRUP—Before proceeding to the particular consideration of the experiments undertaken in the making of syrup, it is essential that the characteristics of such syrup as is found in the market be understood and that the properties of the syrup that is desired or that secures most ready sale be compared with the same, that the necessity for change or improvement and the objects of the same may be noted.

The first essential in any article to be placed upon the market is that it possess a stable or fixed character, composition or quality without which the uncertainty attendant upon its purchase or use is so great as to materially diminish the demand for the same, if not to actually ruin its commercial value.

The highest grade of syrup must have a density or thickness so regular or constant that variations are not detected by superficial or ordinary physical means and which if tested by a saccharometer shows a density of approximately 33 degrees Beaumé. In color it must be entirely devoid of any tinge of green, be distinctly amber, clear and with a perceptibly reddish tint. It should not crystallize, and should be so permanent in composition as to not readily undergo fermentation.

OBSTACLES—That so little syrup possessing the properties here described is actually on the market is self-evident proof of the fact that obstacles to the attainment of the desired results exist to such a degree as to have been thus far insurmountable in practice. Yet syrup with the characteristics described does actually exist and when ever found commands a ready premium, which fact is sufficient incentive toward further striving to an end so unquestionably desirable. Among the causes conducive to the present condition of Florida syrup may be mentioned as of importance and demanding special consideration, the effects of different soils upon the character of the cane produced, the effects of varying conditions of climate and season and the fact that practical and efficient means for controlling results affecting the stability have heretofore been inaccessible.

VARIATIONS IN DENSITY OR THICKNESS OF SYRUP—It is a thoroughly accepted fact that syrup varies so greatly and constantly in density, or thickness, as to destroy its character as a stable market commodity. It was not expected that changes or modifications in method, which might be suggested, would necessarily result in the production of syrup superior to any heretofore known, the object being rather to devise such means of control as would result in constancy of composition whereby all syrup produced by any individual maker would be the same. It is true that most syrup boilers claim that the product produced by them is always constant. Consumers, however, are well aware of the fact that a barrel of syrup obtained from any individual grower of cane today may be wholly unlike that engaged for delivery tomorrow, and that the product of one farm may be as unlike that from a neighboring place as molasses is unlike honey.

To demonstrate the fact that the most skillful sugar boiler could not judge of the thickness of his product sufficiently accurately to make two consecutive runs of syrup identical in density when brought to the test of the saccharometer, the best available sugar boiler, a man with long experience who had made syrup annually on the Station farm for eleven years, was put to the test of comparing his judgment or opinion of the proper density of syrup with the actual test of the Beaumé saccharometer. He was cautioned to make no drawing until to the very best of his judgment the syrup was ready, and that each drawing was to be subjected to a scientific test to determine the degree of his accuracy. He was, therefore, placed on his guard with every incentive to care, deliberation and the best possible action. Different drawings of syrup, each of which was, to the best of his judgment, perfect and in his opinion of the same density as the preceding drawing, were taken and tested with the following results expressed in readings of the Beaumé scale: 34.8, 33, 33.5, 31.5, 37, 32.5, 33.5, 32, 33.5, 34, 33, 34.2. It thus appears that, instead of being as he and most other syrup boilers would affirm, constant in composition, that no two consecutive drawings of syrup were alike in density, and that the variations extended, under every possible precaution, from 32 to 37, a maximum variation of five degrees. It must be borne in mind in this connection that 33 degrees Beaumé is the accepted proper consistency, density or thickness for cane syrup, and that, in the most skillful hands, when personal judgment is depended on, variations of five degrees are possible, and that, in the hands of careless or unskilled makers, the variation must be even greater. The variation in the thickness is demonstrated and the desirability, indeed indispensability, of a feasible means for securing evenness or constancy of quality is established.

Recognizing that some simple means for ascertaining the thickness of syrup was the first essential toward securing stability of product, and further, that the means utilized in the laboratory was wholly impracticable for common farm use, much time and experimental testing was given to this phase of the subject in the hope of devising a simple, easily available, cheap and non-destructible method for determining the density of syrup with scientific accuracy, so that the maker could be assured that every drawing would be exactly like every other drawing, and that the product should be stable and to be depended on.

The thickness of a syrup depends upon its density, and density is controlled by specific gravity or relative weight. The thicker or more dense a fluid is, the less deep will a given solid substance sink therein, because the greater the density of the fluid, the greater its supporting power or buoyancy. The more salt, for instance, which may be present in water, the greater is the floating power of that water. The same fact is true of solutions of sugar. The more sugar present, and consequently the less water in a given sugar solution, or syrup, the greater is the supporting or floating power of that syrup. This is the principle on which saccharometers and other specific gravity or density tests are based, and it is this principle which was utilized as the basis for a simple apparatus devised to meet the requirements of the case and which is illustrated in Fig. 3. It consists of any common botttle which will hold a pint or more of syrup, a pint beer bottle admirably answering the purpose. In the syrup with which this bottle is to be filled a stick is made to float, having first been so weighted at one end with lead that it stands upright in the liquid instead of lying down or resting against the sides of the bottle. This is essentially a specific gravity tube or Beaumé saccharometer, the only difference being that the latter instrument consists of a hollow glass tube with a graduated scale at the bottom of which mercury is introduced as a counterpoise for securing uprightness and equilibrium.

MAKING A SIMPLE SYRUP TESTER—The abovementioned apparatus (see Fig. 3) may be constructed as follows: Take any ordinary glass bottle of a capacity not less than one pint. Take a straight, dry, thoroughly seasoned, hard-wood stick about one-quarter of an inch in diameter and from twelve to fifteen inches long. Fill the bottle with syrup. Roll a narrow piece of sheet lead around one end of the stick, or introduce a few shot into a hollow in the bottom of the same. Drop the stick into the bottle filled with syrup and increase or decrease the amount of lead used until the stick floats upright in the

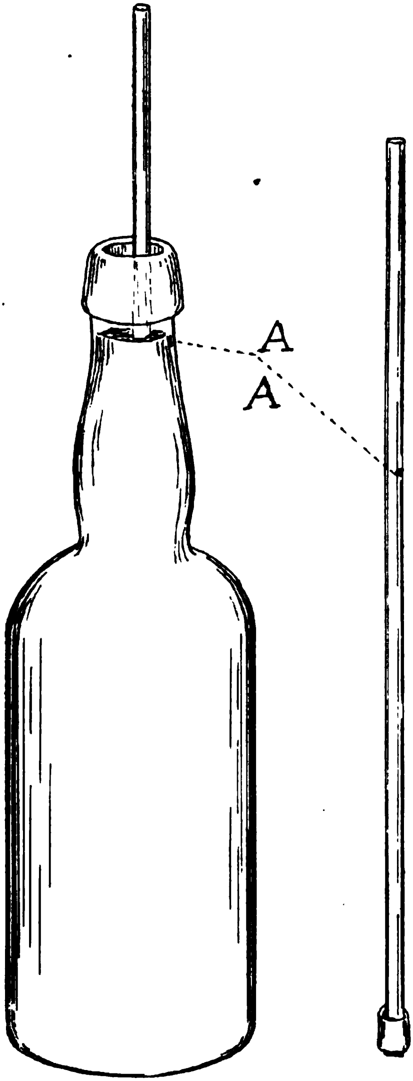

Fig. 3.

A. A.—Point indicating proper density of Syrup.

syrup with at least two inches of space between its lower end and the bottom of the bottle. The apparatus is now complete ecxept for supplying its scale or gauge. To do this, make a run of syrup carefully and continue the boiling until by cooling a small quantity you are positive that it has attained the degree of thickness that is perfectly satisfactory, and which you are willing to accept as a sample or standard for your entire product. Then fill the bottle with this syrup while boiling, drop the weighted stick into the syrup and let it settle carefully until it has reached equilibrium. Mark the place upon the stick at the line reached by the surface of the syrup, preferably by cutting a notch therein or by a black thread tied about the stick. The apparatus is now completed and is ready for use. Test every drawing of syrup, or different drawings, sufficiently often to give a fair sample of the whole, continuing the boiling until our improvised saccharometer, or "syrup tester," sinks into the syrup to the mark or notch made. By this means every sample of syrup drawn or thus tested will be of the same density or thickness as the original sample used as a standard, and there will be no variation in quality so far as density is concerned, but the entire output will be uniform with scientific exactness.

EFFECTS OF VARIETY—Among the factors or conditions modifying the composition and quality of the syrup, the variety of cane used exerts great influence. Two varieties only are sufficiently well known and commendable to demand consideration in this connection. A few facts concerning their relative characteristics, however, seem to be important as furnishing assistance toward governing their selection. These varieties are the common red cane and the green cane. The former is unquestionably much the more hardy and is therefore preferable for more northern localities. It, moreover, possesses the advantage of ripening earlier. This latter fact is well demonstrated by the analyses made of our own crop this year. Moreover, the red cane contains considerably more sugar than the green, but, at the same time, because of the greater amount of coloring matter present in the stalk, gives a darker colored syrup. The average sugar content of the red cane tested at four different periods of ripening the present season was 14.85 per cent, while the green cane showed but 11.94 per cent—a difference of 2.91 per cent in favor of the red cane. The first test of the red cane during the season, on Nov. 20th, showed 14.22 per cent of sugar, while the green cane on the same date contained but 10.10 per cent, a difference of 4.12 per cent in favor of the red cane. At the end of the season, however, the last test made, Dec. 10th, showed the red cane to contain 15.60 per cent and the green cane 15.15 per cent, a difference of but .45 per cent in favor of the red cane. These facts demonstrate that for small areas and the manufacture of syrup in moderate quantities where the full period of ripening can be allowed, the green cane is preferable, inasmuch as the slightly greater degree of sweetness attained by the red cane does not compensate for the darker color of the syrup produced. On large areas, however, where sugar content, hardiness and early ripening are essential, the red cane stands preeminent.

THE EFFECTS OF SOIL UPON QUALITY—It is an accepted fact that quality and texture of soil materially influence the character of the syrup produced, this being particularly true of the effect of the heavier quality of soils and also of certain organic constituents sometimes applied as fertilizers, which result in imparting an undesirable flavor to the product. The only fact in this connection, however, which seems worthy of consideration here is the influence of soil upon sugar content.

Our analyses show an average of 16.60 per cent of sugar in upland cane and 14.99 per cent in bottom cane, a difference of 1.61 per cent in favor of the upland product. It should, however, be remembered that this decrease in sugar content in the cane grown upon bottom lands is explained by the greater luxuriance of growth so that the loss in proportion of sugar is more than compensated for by the increase in yield of cane, a fact wholly in keeping with the universal preference of cane growers for bottom lands for their cane fields.

MAKING THE SYRUP—The first step toward making syrup from cane is the freeing of the juice from the stalk, and the means by which this is to be accomplished is the key to the economy of the process. Although the crudest appliances, even wooden rollers, are capable of expressing juice from which syrup or sugar may be made, still the more juice which can be expressed from a given amount of cane, the greater is the success of the operation. For domestic and smaller manufacturing purposes the simple horse-power mill is commendable. This mill, however, should consist of three rollers, the two-roller mill being so imperfect in action and expressing so small a part of the juice as to be extremely wasteful. A good three-roller mill, with the rollers screwed tightly together, is capable of expressing from seventy to seventy-five per cent of the actual juice in the cane. This matter of keeping the rollers screwed tightly together is one of such importance that it should be regularly looked after and the screws tightened whenever necessary, till the bagasse, or crushed cane, comes through in short pieces.

The juice having been expressed from the cane, the first process in actual syrup making is at an end, and the next step is that of freeing the juice as largely as possible from foreign substances. In common farm practice this consists simply in straining it through a gunny-sack as it comes from the mill. This, however, although desirable, only suffices to remove from the juice the small particles of cane that pass from the rollers. There remain many other foreign substances, the presence of which is detrimental to the quality of the syrup and the removal of which is indespensable to securing of the best product. Chief among these are coloring matters and the so-called non-sugar carbo-hydrates and albuminoid compounds. The method which has been universally recommended by the Experiment Stations for accomplishing this removal consists of sulphuring and liming the juice. The first process being to subject the juice, as it comes from the mill, to the action of sulphurous acid fumes obtained from the burning of sulphur in a furnace constructed for the purpose, and then the removal of sulphurous acid by defecation of the juice with milk of lime in a separate pan or boiler before the actual process of evaporation begins. That the method accomplishes the object sought and results in a superior quality of syrup there can be no question. That it is comparatively expensive, inconvenient and impractical for general domestic use is, however, equally true and is abundantly demonstrated by the fact that, though the method has been recommended by every publication issued by an Experiment Station treating of syrup-making during the past decade, the method has not actually been adopted by one syrup-maker in a hundred.

In view of these facts, a series of experiments was undertaken in the hope of devising a simple and practical means so inexpensive as to be within reach of all and so easily available that the means for using the same might be secured without effort on any Florida farm. These experiments were divided into two clases—first, the filtering or freeing of the juice from foreign materials by purely physical means, and second, the defecation or precipitation of impurities remaining in the juice after filtering.

FILTERING THE JUICE—The experiments in filtering included the use of every material which has ever been suggested for the purpose by reliable authorities and a trial of numerous new materials which it was conceived might possibly accomplish the end sought.

It is not deemed necessary to go into particulars as to the effect of each material used, but to simply give the list of these materials and the details recommended to be followed with the article having shown most satisfactory results. The filtering materials tried included straw, hay, seed-cotton, cotton-lint, sand, shavings, excelsior, sawdust, ground excelsior, charcoal, fuller's earth and Spanish moss. The last material was so unquestionably superior to any other used that it was adopted as the best and most feasible article for the purpose, and was used exclusively after its advantages were demonstrated.

The method of use was as follows: Dry moss, such as can be obtained anywhere in the State of Florida, was carefully picked, and freed from leaves, sticks and foreign matter and thoroughly washed. A tub, or half-barrel, through the bottom of which a hole for the outlet pipe was bored, was taken and a piece of perforated tin was placed over this outlet on the inside of the bottom of the tub. The tub was then filled with the cleaned moss, which was packed as solidly as it could be crowded in by the weight of a man, until it was filled. It was then placed under the outlet gutter from the mill and the juice was conducted upon the moss in the center of the tub by a tin trough. This juice therefore sank by gravity through the entire thickness of moss till it found outlet through the pipe-hole in the bottom through which, by means of a half-inch iron pipe, it was conducted by gravity to the skimming pan. The passage of the juice through the moss not only freed it of all coarse and floating foreign particles but filtered out a very large proportion of the non-sugar contents and coloring matter so that the juice passing through the outlet pipe was nearly as clear and colorless as water. The only precaution necessary in using this method is, that the moss naturally occasionally becomes clogged and requires renewing once in two or three days of constant running, but in warm weather it was found that the juice adhering to the moss in the tub was liable to ferment over night and be sour in the morning, under which circumstances it is necessary to replenish the filter with fresh moss before beginning work in the morning.

The advantages claimed for this method are its simplicity, cheapness and effectiveness. It accomplishes all that has been claimed for the sulphuring process, and yet is so easily available as to be accessible to any farmer in Florida, practically without either trouble or expense.

CLARIFYING THE JUICE—Satisfactory and effective as the above described method proved itself, it is not sufficient for securing such results as we aimed at, further clarifying of the juice being still desirable. For this purpose the usually recommended method is the use of three different pans or vessels, in the first of which after sulphuring, the juice is treated with milk of lime. The objections to this method have already been stated in connection with the sulphuring process as a whole. A simpler method was deemed indispensable if the same was to be recommended for general domestic use. The first recommendation in this connection which is offered as that securing the finest product, whatever may be the means by which the juice is finally converted into syrup, whether the evaporation be conducted in an iron kettle or an evaporating pan, clarifying or skimming of the juice should be effected in a different vessel from that in which the final condensation of the syrup takes place. Our experiments were made with the use of a common shallow Chattanooga evaporator. The filtered juice as it came from the filter was conducted into an open pan of the same size as the evaporator but about eight inches deep, such as can be made by any tinsmith. This was placed upon a brick furnace, side by side with the

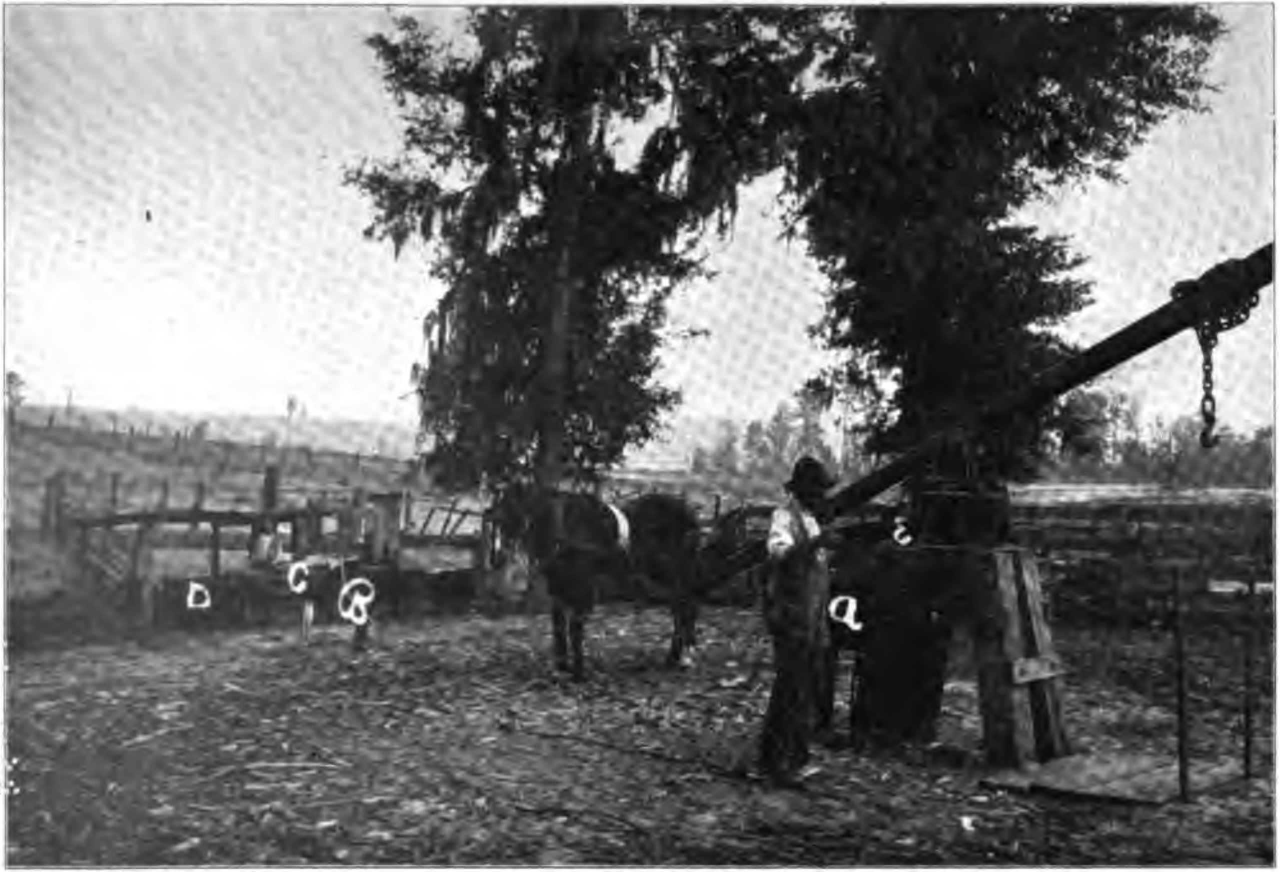

Fig. 4.

A. Moss Filter. B. Pipe from Filter. C. Clarifying Box. D. Evaporator. E. Cane

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evaporator, with a space of about six feet between the two, so that both pans and fires could be tended by one man with no material increase in labor. It should be added, however, that there was very little if any increase in fuel needed, inasmuch as the heat required for raising the juice to the boiling point in the first pan was not required in the evaporator, hot juice instead of cold being introduced into the latter, there being a half inch connecting pipe extending from the bottom of the first pan to the evaporator. This introduction of a second pan is deemed in every way indispensable to the securing of best results, whatever may be the treatment of the juice or the method of final evaporation, even in the event a common iron kettle is used for finishing the syrup. The advantages of this supplementary pan lie in the fact that where the boiling, skimming, evaporating and condensing all take place in one kettle or evaporator, it is absolutely impossible, except where work is conducted on the smallest possible scale and with constant personal care, to prevent the mixing of unskimmed fresh juice with the partially finished syrup, or of imperfectly removed scum with the nearly completed syrup. These contingencies, however, are wholly avoided when the syrup is raised to its boiling point in a separate pan in which all of the skimming is to be done so that only perfectly clear, hot juice is introduced into the finishing pan, kettle or evaporator. A further precaution is to be recommended, viz., that the juice from the mill, instead of being conducted directly into the first pan, be reservoired or held back in a trough or barrel so that the contents of the pan may be allowed to flow into the evaporator as required, in which no skimming whatever will be necessary and the syrup produced will be entirely free from all contamination resulting from the presence of unremoved coloring matter.

PRECIPITATION BY FULLER'S EARTH.—A modification of the above method was resorted to experimentally by the introduction of fuller's earth into the first pan at the rate of one pound of earth to five gallons of juice and bringing the contents to the boiling point, when all the coloring matter and albuminous impurities, ordinarily forming a scum upon the surface, were immediately precipitated to the bottom of the pan, leaving a perfectly clear and almost transparent fluid behind, which is easily drawn off with syphon or through an outlet pipe placed about one inch above the bottom of the pan. The cost of this method with fuller's earth worth $14 per ton is very slight, and the earth exists in large deposits in several parts of the State. So far as actual results are concerned, the syrup produced by this modification compares in every way favorably with that obtained by the simple skimming of the juice, but it does not possess advantages over the same. The method, therefore, possesses merit, but is hardly yet to be recommended for general use except in cases of highly colored juices from which inferior syrup is produced by the other method.

FINISHING AND TESTING THE SYRUP—However clear the clarification may have been, the quality of the syrup will be largely controlled by the final boiling to which it is subjected. For this purpose, because of the very much greater control possible, steam heat is preferred. It is, however, recognized that on most farms circumstances will prevent the untilization of steam for evaporation, and that open fires under kettles and evaporators must continue the chief recourse. Care, however, must be exercised that the syrup shall be kept boiling at as near as possible an even temperature and that the supply of syrup in the evaporator be so constant that scorching is impossible, slight scorching being detrimental both to taste and color of the product. The point at which the boiling should cease and the finished product be removed from the evaporator is the crucial test of the skill of the operator and the quality of his product. As has already been shown, however, the best human judgment will frequently fail on this point, and the only safeguard lies in subjecting the syrup to the actual test of the apparatus or tester already described and illustrated, by means of which all variation in density of product is rendered absolutely impossible.

It is well to add, however, that the approximate finishing of the process may be easily recognized by allowing the syrup to drip from the edge of the skimmer or paddle, and if the drops flow together and stretching out form a thin film upon the edge of the skimmer as they fall the time for actual testing with the apparatus mentioned has arrived.

PRESERVING THE SYRUP—As already mentioned, the heretofore nearly insurmountable obstacle toward placing the syrup upon the market as a commercial product has resulted from the fact that as ordinarily made and marketed it was so unstable as to undergo fermentation, deterioration or destruction within a comparatively few weeks or months at most. There have been many methods proposed for overcoming this difficulty, all of which, however, including the sulphuring and liming already mentioned, have rested upon the introduction of a foreign substance into the syrup to counteract its natural tendency, rather than upon the removal of the actual cause of this tendency. Our experiments and methods have been conducted on the supposition that this fermentation or destruction of the syrup was due not so much to any inherent property of the syrup itself as to the presence of impurities, the elimination of which would necessarily be followed by a disappearance of the trouble. In other words, that thorough purification and clarification of juice and syrup would necessarily result in improved keeping qualities in the product.

The methods already described as practised by us have apparently demonstrated the correctness of this supposition, indeed at the time of the present writing we have samples of syrup made by the method described which have been exposed in open vessels in a warm room for three months without the slightest fermentation, crystalization or deterioration. It is recognized, however, that the process of decomposition, resulting in the deterioration of the quality of the syrup depends for existence upon access of air, and that in the absence of air the process is materially checked or absolutely prevented. The natural suggestion, therefore, is that syrup, for preservation, should be put up in some receptacle in which it may be hermetically sealed when hot. Bottles, jugs and similar articles have been more or less used for the purpose, but a careful consideration of all the facts involved leads to the conclusion that the ideal syrup receptacle is a tin can of moderate size which may be sealed air-tight and afterwards handled easily with no possibility of injury to contents.

This brings us to a matter worthy of special consideration.

THE MARKETING OF SYRUP.—Unless preservation of the product is assured it is recognized that there will be little syrup to market, and therefore preservation and marketing are most intimately associated. Moreover, except for domestic consumption upon the farm where produced, the marketing returns from the product must control the success of the process. This phase of the subject, therefore, is deemed of special importance. The syrup made by the process described has not only been pronounced by experts to be superior to anything heretofore available, but it has actually been placed on the market for the express purpose of determining its actual relative commercial value, on which the merits of the process must finally rest.

Preservation, ease of handling and cost of marketing were the points considered. The different forms of receptacle or package heretofore utilized were tried and, one by one, discarded as faulty. Barrels are bulky and imperfect preservers; in them fermentation is probable. The

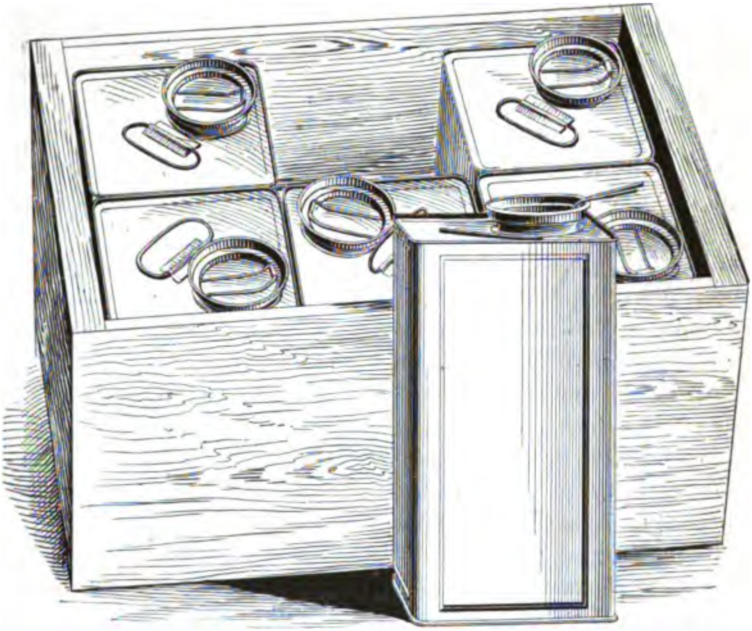

Fig. 5.

common cypress barrel, moreover, with all its advantages should be rigorously discarded as the receiver for first-class syrup such as is aimed at. If the syrup is turned in while hot and the barrel, as is usually the case, is new, the contents almost invariably acquire a foreign easily detected taste very materially detrimental to the value of the article. This is true, also, of old barrels and cold syrup, it being even then sufficiently perceptible to detract from the quality of the syrup. Bottles are expensive, destructible, inconvenient to fill and difficult of transportation, and though good preservers when tightly stoppered and sealed are recommended only for home use. Some form of tin can, therefore, seems to be the only commendable recourse. After careful consideration of the advantages presented by different forms and sizes, the one-gallon square can with a wide orifice, closed air-tightly by a cap surrounded by a rubber ring and fastened by the so-called lever action, was adopted by us and is recommended. In this the syrup should be introduced while hot, first being strained through a thickness of cotton flannel to prevent the possible introduction of specks or accidental impurities. These cans are obtained in boxes or crates containing six cans each, in which they should be shipped, and syrup thus put up will maintain its quality uninjured indefinitely, possessing, moreover, very great convenience for handling, storing and shipping. The can and its construction are well represented in the accompanying illustration. (Fig. 5.)

As to the commercial value of the method followed a few facts are important. The common syrup of the farm, for which the county in which the Station is located is well known, has averaged during the season in the markets of Lake City 15 cents per gallon in barrel lots. Our syrup in barrels is sold in any quantity we have been willing to market for 25 cents per gallon, net, barrels being returnable to us. Shipments of syrup in cans have netted 50 cents per gallon, the cost of the cans being 10 cents each, though larger quantities could have been secured at much lower rates. Of the profits of the process of making and the method of shipping, therefore, there can be no question. It is only necessary to add further that the process having been put to the test of actual remunerative returns, can be recommended to others without hesitation or reservation.

III.

SUGAR.

Although the making of syrup was the chief experimental work undertaken, incidentally some attention was given to the process of sugar-making with the object of further developing this domestic industry in the State. It is not to be expected that the home manufacture of sugar can take its place as an important commercial undertaking upon many Florida farms, the capital and acreage required making sugar production essentially a manufacturing rather than an agricultural enterprise. It is believed, however, that conditions of climate and soil, if properly utilized, would naturally place Florida in the lead as a commercial sugar-producing State, and that capital invested in this business in Florida would certainly be more remunerative than is possible in any other part of our country. As bearing on this point, a comparison of the sugar content of Florida cane with the average for the state of Louisiana is mportant. Dr. Stubbs, Director of the Louisiana Experiment Station, places the average for his state at 12 per cent.* This amount is somewhat above the average of available analyses, but is adopted as sufficiently high.

Our analyses of Florida cane from eighteen different localities covering the entire state the present season show an average of 15.69 per cent of sugar, and an average coefficient of purity for the juice of 86.30 per cent. The Louisiana comparison is 12 per cent of sugar and a coefficient of purity of 80.50 per cent. A difference of 3.69 per cent of sugar and 5.80 per cent of purity in favor of the Florida product. There is no question of equally heavy crops in our state so the superiority of Florida for sugar production can hardly be longer questioned.

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*From a very kind personal letter to the Author.

This Bulletin, however, is devoted essentially to the interests of the average farmer of Florida rather than to the consideration of exceptional conditions. So far, therefore, as it can touch upon the question of sugar production it will deal solely with the domestic phase of the industry in the hope of enabling intelligent growers of sugar cane in our State to utilize a portion of the same for more economically and satisfactorily supplying their own home and local requirements. It must be borne in mind that all that has thus far been recorded pertaining to the growing of cane and the making of syrup is equally applicable when the ultimate end in view is sugar rather than syrup, the essential difference being that the process is continued farther.

The Spanish moss, double-pan method recommended for syrup is also equally applicable and commendable for sugar.

BOILING FOR SUGAR.—After the syrup stage has been reached, if sugar is desired, great care should be exercised that all danger from scorching or overheating may be avoided. Indeed, the lower the temperature, the less the actual amount of boiling till the density necessary for sugar forming is reached, the better. High temperature and vigorous boiling having a tendency to invert the sugar and thus prevent crystallization, should be carefully guarded against. Indeed, so important is this fact that the crude iron kettle, with all its faults, possesses some advantage as the finishing receptacle in sugar boiling because of the less surface exposed to direct heat and consequently the diminished danger from over boiling. After the syrup stage has been reached, as determined by our improvised "syrup tester," the process should be continued according to temperature for twenty or thirty minutes, at which time the density should have proceeded about one-tenth beyond the syrup stage. In other words, the volume of the syrup should have been diminished by about one-tenth.

The final test for determining when the proper consistency has arrived does not rest entirely upon density or thickness, and therefore the saccharometer is useless. The test must be the actual crystallization of the sugar. If, however, a sample of syrup is found to grain and it then be tested with the "syrup tester" and an additional or lower mark be placed upon the stem of the same, this will serve as the safest indicator of the proper time to stop boiling for future runs.

When the syrup has been condensed, as mentioned, it should be removed to a barrel, tub or trough, or where a kettle is used it may be allowed to remain in the same after withdrawal of the fire.

GRAINING—The condensed syrup is now ready for graining or crystallization, which process will inevitably take place in it, but may be advantageously hastened by stirring the mass while cooling with a stick or wooden paddle. Not only is the process of crystallization or sugar formation thus hastened, but the quality of the product, particularly its degree of whiteness, is very materially improved thereby. The time which will be required for completing this graining process will depend upon density, amount of impurities present and the relative sucrose or sugar content of the syrup. With reasonable success in quality, the period, however, should rarely continue over one hour, and may be completed in a very few minutes. When the graining or crystalizing has been thus effected the process is, for the time being, at an end.

PURGING.—The soft sugar thus formed is a mixture of sugar and molasses, and the next step in the process is the separation of these two constituents. This is best and most simply effected by turning the soft mass, the so-called *masse cuit*, into flour barrels, through the bottom of each of which three or four one-inch auger holes have been bored, into each of which a stalk of cane as long as the barrel and from which three peelings have been taken their entire length, should be thrust. The barrels filled with the *masse cuit* should then be placed on blocks, benches or tables so that they are raised sufficiently from the floor or ground to allow the placing of a pan, tub, or crock under each barrel for catching the molasses as it runs off. Time alone will now complete the process, the purging going on by gravity without human assistance. It is complete when the molasses has so drained off as to leave the sugar reasonably dry and free from all sticky tendency.

If the process is successful such sugar will be of a light brown or yellowish color, and thoroughly adapted to most domestic uses, and will find ready sale for local con-consumption, or for refining.

WHITENING THE SUGAR.—The demand of the market and perhaps, unfortunately, of most consumers is for sugar entirely free from all natural cane flavor or taste and perfectly white in color—in other words, the "granulated" form of commerce. This product, however, is the result of the refining process involving the use of complicated machinery and great capital. There are, however, simpler means by which, on a small scale with a moderate expense, the sugar may be so materially whitened as to approach the character of granulated sugar and find more ready sale. The simplest of these methods is one devised by us but based on a modification of an old process used in the days when loaf sugar was a standard article of commerce. It consists simply in removing the sugar from the purging barrel and placing it in a tub or half-barrel with an outlet at the bottom. The sugar is then covered by a single thickness of common cheese cloth, on top of which is placed a water bucket-ful of moist clay stirred to a thick paste. The result will be that the sugar will absorb the moisture from the clay and become washed thereby; in a few days' time the sugar will have become so materially whitened as to better meet the popular demands, indeed, will approach in character and appearance the very best product of commercial sugar below the grade of "granulated."

A modification of this method may be advantageously used, based on the practice in many sugar refineries and in all laundries, viz.: Blue is optically complementary to yellow and, consequently where blue and yellow are brought together in opposition, the neutral or white optical effect follows. Consequently, the laundress uses bluing with yellow clothing to make it appear white, and the sugar refiner uses ultra marine upon his yellow sugar whereby it appears white. Ultra marine is wholly harmless and inexpensive, and can be secured of most druggists. If the water, therefore, that is used for mixing with the clay is *very slightly blued* by the introduction of a little powdered ultramarine the effect is an apparently white sugar really no purer or whiter than the yellow article, but which meets the public demand and sells for a better price.

YIELD AND RETURNS FROM SYRUP AND SUGAR.—The final value of any crop must rest upon its commercial returns, whether the same is actually placed upon the market or is used for home consumption, since in the latter case, expenditure is prevented and "a penny saved is a penny earned." In the particular case of sugar cane, however, it has been, as already expressed, my desire to show that the growing of cane for the manufacture of sugar offered a remunerative crop thoroughly adapted to Florida conditions, and therefore a most valuable substitute in regular farm practice for other staple crops which have been unremunerative. The yields and value of the returns from a crop of cane, therefore, are of particular interest. My own experience and the various replies received from the letters sent to many cane growers in the State indicate than 500 gallons of syrup per acre is a reasonable product which may, with intelligent management, be counted on as almost certain, while exceptional crops are known to sometimes return fully twice this quantity of syrup. Such syrup as I have described and have shown can be easily made with certainty, finds constant and ready demand in the market at a net return of 25 cents per gallon, or a gross return of $125 per acre of cane. I believe that this acre of cane can be grown, and its product can be manufactured into syrup at an average cost of $75 per acre, leaving a net profit on a very moderate basis of $50 per acre from the crop. The same syrup, if marketed in the condition I suggest, will easily double the returns.

If sugar is the product in which the crop is finally marketed, an estimate made on the same basis and from the same data leads me to place the reasonable yield at 3,000 pounds of sugar per acre with the simple domestic methods described. This sugar finds ready sale at 4½ cents per pound net, or a gross return of $135 per acre. In addition to this the molasses obtained must be taken into consideration, although its quality does not give it a fixed commercial status. The expense of producing sugar is nearly one-tenth greater than that of making syrup, or $82 per acre, leaving a net profit per acre of cane manufactured into sugar of $42. Although it, therefore, appears that the crop is more profitable when converted into syrup than when manufactured into sugar, still the combination of the two is commendable, at least to the extent of supplying home demand. It will, therefore, be seen that the sugar cane crop on a purely commercial basis can be made one of the most profitable resources of the Florida farmer, aside from the mere advantage of domestic independence.

In conclusion I desire to express sincere thanks to the many citizens of the State who have kindly assisted me in procuring the data used in this Bulletin, and particularly to Professor Persons and Mr. Davies of the Chemical Department for the courtesies and assistance rendered.

H. E. STOCKBRIDGE.

BULLETIN NO. 45. MARCH 1898

FLORIDA
Agricultural Experiment
STATION.

Three Injurious Insects.

BEAN LEAF-ROLLER.
CORN DELPHAX.
CANNA LEAF-ROLLER.

—BY—

A. L. QUAINTANCE.

The Bulletins of this Station will be sent Free to any Address in Florida upon Application to the Director of the Experiment Station, Lake City, Florida.

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Summary.

I. THE BEAN LEAF-ROLLER.

(a) The bean leaf-roller is quite destructive to beans throughout the State. The larvae feed upon the leaves, eating holes in them or eating along the edges. Leaflets are folded over, to form a retreat, (see figure 5. plate I).

(b) The larva is about one and one-fifth inches in length, fusiform in shape, the body being thickest in the middle, with small neck and large head. The general color is yellowish, with a dorsal black strip, and two lateral orange stripes extending down the body (see figure 2, plate I).

(e) The insect can be successfully treated. Use Paris green, in the proportion of one pound to 150 gallons of water; add to this one pound of quick lime, first made into a thin paste, to destroy the burning effects of Paris green on the foliage. Apply with spray pump, keeping mixture well stirred.

II. THE CORN DELPHAX.

(a) The corn delphax has been observed in several localities in the South, as very destructive to corn. It is a sucking insect, feeding on the sap, which it sucks from the leaves and stalk, thereby causing them to yellow, and frequently die. The insect is injurious in all its stages.

(b) In earlier stages the insects are quite small, yellowish in color, congregating in large numbers in protected places, as between a leaf-sheath and the stalk. The adults are about one-tenth of an inch in length, brownish yellow in color, more or less clouded with dusky. There are two forms of adults, a long, and short winged form. Adults and more mature nymphs occur out on the leaves and stalk. In all stages, save the first, they jump readily or sidle around the stalk or leaf when disturbed. (See figures 4 and 5, plate II.)

(c) The best treatment is probably to be found in the destruction of infested plants by burning. Fields infested with this insect should not be planted to corn or other crops belonging to the Gramineae.

III. THE CANNA LEAF-ROLLER.

(a) This insect has been very injurious to cannas for the past three years at Lake City. The larvae are leaf rollers, living within the roll, eating out the parenchyma of the leaf. Infested leaves soon die, becoming brown and ragged in appearance, thus destroying their value as ornamentals. (See figure 7, plate III.)

(b) A full grown larva is about an inch in length, small bodied, cylindrical, of yellowish white color. (See figure 2, plate III.)

(c) The destruction of the larvae is probably best accomplished by cutting off the dried up canna leaves during the winter and burning them. Also in cutting off and burning infested leaves when first noticed in the spring.

The Bean Leaf-Roller.

(*Eudamus proteus*, Linn.)

The "roller-worm" has been recognized as a garden pest in Florida for many years. In the Annual Report of the United States Department of Agriculture for 1880, Prof. Comstock mentions having observed this insect infesting various garden crops in different parts of Volusia county; beans, turnips and cabbage being seemingly preferred. Last year seems to have been a "roller-worm" year, judging from the numerous complaints that have come in from correspondents in various parts of the State against it. In most cases it has been reported as destructive to beans, but in two or three instances, it has been reported as injurious to a number of different garden crops.

In the vicinity of Lake City the writer has not observed them on other crops than beans, but on this plant it has frequently been sufficiently abundant as to almost destroy promising bean fields. Larvae have also been frequently observed on the "beggar-weed" (Desmodium tortuosum, D. C.) and other species of this genus. It seems possible that these Desmodiums are the natural food plants of this insect. The first brood comes out early in spring and a succession of generations continue until stopped by cool weather. In the southern part of the State, breeding may be continuous throughout the year. The writer observed them in considerable abundance in the bean fields along the East Coast during the last of December and January.

LIFE HISTORY AND HABITS.

This insect has been studied repeatedly through its various stages. During the summer the life cycle is quite short, requiring in some cases only twenty-four days from the depositing of eggs, until the emergence of the adult from the pupa. On June 3rd, adults were observed depositing eggs on the lower surface of bean leaves. Several of these eggs were collected and brought to the insectary. These hatched in four days. The larvae grew rapidly, going through five moults, and fourteen days from the time of hatching, five entered the pupal state. Six days later, three adults emerged, one male and two females. The life cycle was found to extend over a period of thirty-seven days, during October and November, and specimens are now (Dec. 8th) in the pupal stage, that were collected as eggs thirty-two days earlier, and it is not improbable that these will continue as pupae until the warmer weather of spring, when the adults will appear.

Eggs deposited on bean plants, are usually, if not invariably, placed on the under surface of the leaflets, in groups of from one to six. Frequently they are placed in columns, three or four eggs high, usually two columns placed together, and evidently deposited by one female. The basal egg is quite firmly glued to the surface of the leaf, and the superimposed egg, to the one next below it. Curiously enough, so far as I have observed, the distal egg is the first to hatch.

Upon hatching, the larvae soon begin to feed, eating out small patches of parenchyma from the leaf. During the course of the next twenty-four hours, a larva usually prepares a retreat, by folding over a flap of the leaf. The flap is triangular in shape and is formed by the larva cutting along two converging lines from the margin of the leaf and inward a distance of five or six millimetres (.23 in.) where the flap is left attached by a small connection. This is then folded quite over against the surface of the leaf and the larva spends much of its time within this retreat, going out, however, to feed. When ready to moult, the flap is fastened tightly down on all sides, and the moulting occurs within this retreat. These triangular flaps are used until the larva has passed into the third or fourth stage, when a retreat is formed by folding over a leaflet parallel to its mid-rib. The larvae do not usually feed within these rolls, but crawl out sometimes six or seven inches from the retreat and feed upon the surrounding foliage. Instances are sometimes observed, however, where the retreat has been partially eaten. (See figure 5. plate I.) The young larvae prefer the upper surface of leaves, and these flaps are almost invariably folded upon the upper surface.

Larvae bred in the insectary invariably pupated within a folded leaflet, or several leaflets fastened together. Notwithstanding diligent search, I have never been able to find a pupa in the field, in a folded bean leaflet or elsewhere, and have been led to suspect that the pupa state may possibly be passed in the soil.

Considering the life cycle as averaging about thirty days, eight or nine broods could occur during the year, since they appear early in March and continue breeding usually through December, in this latitude. However, the broods are not distinct; eggs, young and old larvae and adults are found in considerable abundance by early summer, as before mentioned. In the more southern parts of the State, where food is abundant, breeding may be continuous throughout the year. Both larvae and adults are diurnal in their habits, moving about freely at all times of the day.

DESCRIPTION.

EGG—Sub-spherical in shape, flattened below, and slightly so above; marked with raised lines or ridges, running vertically up the egg, which converge at the polls. On the upper one-fourth, numerous cross ridges occur (figure 1, plate I); diameter .966 mm. (.037 in.); length .825 mm. (.032 in.).

When first deposited, the eggs are clear glistening white in color, which in the course of a few hours becomes clear yellowish. The dark head of the embryo may be readily located in the more advanced stages of embryonic development.

LARVA, FIRST STAGE—Length, 2.1 m m. (.081 in.); width of head, .566 m m.; width of body across third thoracic segment, .4 m m. (.015 in.). Shape of head almost circular in outline, as seen from in front. Body sub-cylindrical in shape, tapering slightly caudad from about tenth segment. Color of head brownish-black; V shaped suture extending about half way up in front; strong median suture extending to top of head from the apex of V. Antennae three jointed, distal joint very small, short and cylindrical; basal joint bears a seta extending one-third its length beyond distal joint. Second joint bears two or three short, fleshy processes, and a long, slightly curved seta. Distal joint bears two or three short, fleshy, unequal protuberances. Color of body, uniform yellowish above, lighter below. Prothroacic shield, brownish-black. Legs, yellowish; claws brown; pro-legs normal, each with complete circle of brownish colored hooks, except in the case of the anal prolegs, where the hooks are absent in the posterior one-fourth of circle. Tubercles are well developed, I-V, each bearing a well developed and somewhat blunt ended seta. VI and VII are less developed with their respective seta pointed.

SECOND STAGE—Length, 3.16 m m. (.123 in.); width of head, .866 m m.; width across third thoracic segment .7 m m. (.027 in.). Head circular in outline as seen from in front. Body sub-cylindrical, tapering slightly cauded as in 1st stage. Color yellowish green, lighter below. Numerous blackish dots and splotches sprinkled over dorsal surface. Prothoracic shield jet black; the yellow lateral lines so conspicuous in the adult larva, are faintly intimated in this stage. Ventral portion of first thoracic segment reddish. Legs and prolegs as in first stage.

The tubercles of the first stage seem to have disappeared with the first moult. The body dorsally, is thickly covered with short hairs, with truncate, serrated or angled ends. Ventrally, the hairs are pointed. Numerous hairs are also distributed over the head.

THIRD STAGE—Length, 1 c m. (.39 in.); width of head 2 m m.; width of third thoracic segment 1.5 m m. (.058 in.). Head cordate in shape, distinctly lobed above. Body sub-cylindrical, tapering slightly as in preceding stages. General color, greenish yellow; dorsally, thickly peppered with black; lighter below, with the black wanting. The yellow lateral lines much more distinct than in stage II, being now plainly marked. Posteriorly, these merge into broader orange streaks, which extend from about the tenth segment, caudad. A narrow black line extends down the middle of the dorsum from prothoracic shield to tenth segment. A faint whitish sub-spiracular line extends from prothoracic

PLATE I.

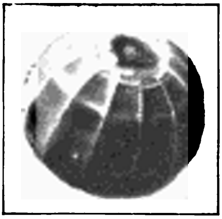

Fig. 1.

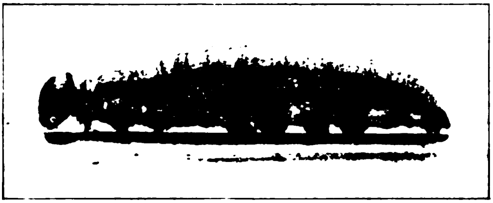

Fig. 2.

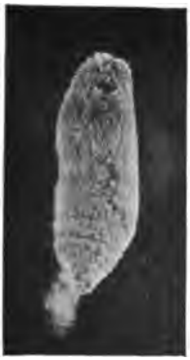

Fig. 3.

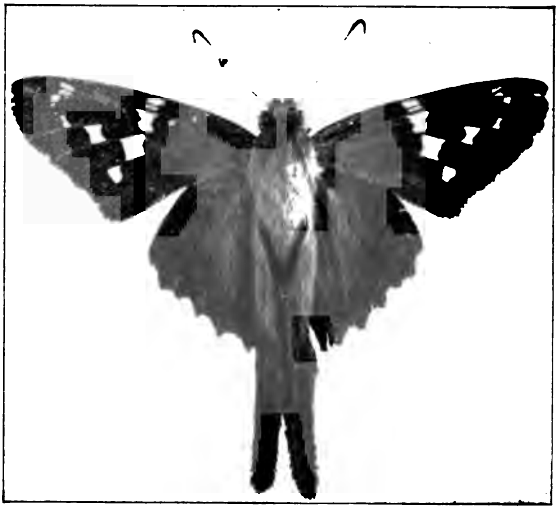

Fig. 4.

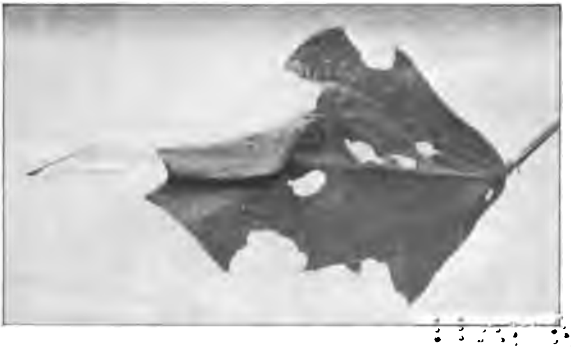

Fig. 5.

Eudamus proteus.—1, egg; 2, larva; 3, pupa; 4, adult; 5, bean leaflet showing work of larva. Figure 1 greatly enlarged, from photomicrograph; Figures 2, 3 and 4, enlarged about two-thirds diameter. All from photographs.

M 10U

shield to caudal end. Prothoracic shield black; ventral portion of first segment reddish. The first two pair of thoracic legs blackish, third pair clouded with dusky. Each abdominal proleg is marked on the outside with faint orange spots. Tubercles and setae of first stage absent. Body and head covered with short hairs as in stage second.

FOURTH STAGE—Length 1.5 c m. (.585 in.); width of head, 3 m m.; width across third segment, 2.25 m m. (.087 in.) Color and shape about as in third stage, except the markings are more pronounced. On the head, near the base of each mandible, is a circular orange spot; the apical portion of the head is rufous; thoracic legs shining black. Ventral portion of first segment deep red.

FIFTH AND LAST LARVAL STAGE—Length, about 3 c m. (1.17 in.); width of head 4.5 m m.; width across third segment, 5 m m. (.195 in.). Shape of body somewhat fusiform, thickest about the middle, and tapering slightly to each end. Head as in preceding stages—somewhat cordate in shape, quite large. Color yellowish, sprinkled with black as in preceding stages; lighter below, without black markings. The lateral yellow lines of the preceding stages, more orange colored. Narrow dorsal line present. Two broken rings of orange on prolegs. Head with the usual orange spots near the base of mandibles; the apical third of head rufous, the rest black. Prothoracic shield black, ventral portion of this segment dark red. Thoracic legs black; head as in preceding stages; greatly constricted behind forming a narrow "neck." Body and head covered with numerous short, light colored hairs. (Figure 2, plate I.)

PUPA—Length about 2.25 c m. (.877 in.); width about 6 m m. (.234 in.). At first, greenish yellow in color particularly the wings and thorax; at length, shining brown in color; eyes brownish black. In the course of two or three days the pupa becomes covered with a white flocculent excretion. The cremaster consists of numerous brown hairs with curved tips, forming hooks. (See figure 3, plate I.)

ADULT—The adult insect, or skipper, may be recognized by reference to figure 4, plate I. The wings expand about 5 c m.

(1.95 in.). On the base of primaries, basal half of secondaries, and on the dorsum of the abdomen, are metallic green hairs. The primaries are marked with five to seven square rectangular, or oblong white spots, confined to the distal half. The secondaries extend caudad into long tail-like processes, making a total length from head to tip of secondaries of about one and one-half inches. Under side brownish purple; primaries about the same in color as on upper surface. Secondaries marked with two oblique markings of deep purple black, the inner strip much interrupted. Under surface of tails deep brownish black; tails tipped with rufous. Antenna terminates in a recurved hook.

TREATMENT.

The bean leaf-roller can be successfully controlled with Paris green. Experiments made indicate that if the poison is used at the rate of one pound to one hundred and fifty gallons of water, this will be sufficiently strong to destroy the larvae. But under certain conditions the foliage of the bean plant is scalded by using a spray of even this low strength of Paris green. In one case, where the insecticide was applied of the above strength, a rain occurred about thirty-six hours later, which resulted in the killing of the plants, due, doubtless, to the increased amount of arsenous acid put in solution by the rain. To obviate such results, quick-lime should be used in the mixture, as the lime will nutralize the arsenous acid, and so far as past experiences show, do no harm to the plants. It is usually quite sufficient to use equal amounts by weight of lime and Paris green. Before adding the lime to the Paris green and water, it should be mixed with water until it has about the consistency of paint, care being taken that all particles are dissolved completely, and trash removed, so that the nozzle of the pump will not become clogged up in spraying.

The Corn Delphax.

(*Delphax maidis*, **Ashmead.**)

During the latter part of August of the past year, a plot of corn on the Experiment Station was found to be badly infested with this insect. These insects suck the sap from the plants with their strong beaks, thereby greatly retarding development, causing them to yellow and frequently to die. A not infrequent result of the puncturing of the plant by the insect, is the exudation of drops of a clear, slightly sticky fluid from the wounds; ants attracted by this saccharine fluid are usually to be observed in considerable numbers, and their presence in undue abundance should be cause for examination.

This is not the first instance in which this insect has been observed to be a corn pest. In June, 1888 Mr. W. H. Ashmead observed them as very severe on corn at Jacksonville, Fla.. and during the past summer it has been recorded by Prof. H. A. Morgan, of the Louisiana Experiment Station, as very destructive to Mexican June Corn growing upon the sugar Experiment Station at Audubon Park.

Mr. Ashmead has contributed much to a knowledge of the life history and habits of this insect in an article in the March-April number of Psyche, 1890, page 321. An interesting statement in this article by Mr. Ashmead is to the effect that many years ago (1841) Prof. Westwood published an illustrated description of an insect very closely allied to the corn Delphax which was seriously destructive to sugar cane in the West Indies. We must consequently be rather suspicious of this corn pest as it is liable to widen its range of food plants, and attack the sugar cane. Feeding as it does on the saccharine juices of the corn, it would possibly find the sugar cane even more palatable—and we should take care that we do not import Westwood's insect from the West Indies.

The abundance of the insects during late summer and fall of the past season offered splendid opportunity for the study of this pest both in the field and laboratory. The results of this study are herewith given.

HABITS AND LIFE HISTORY.

Eggs are deposited mainly along the mid-ribs of leaves down in the loose cellular tissue just beneath the epidermis. The mid-rib of the lower leaves is usually quite packed with these eggs, more numerous near the base, but frequently extending almost out to the tip. These numerous punctures in the leaf are a serious detriment to the plant, and doubtless help to hasten its death. The number of eggs deposited together in the same slit, and evidently by the same female, varies from two to four. Probably in the majority of cases but two eggs are deposited together, but there are very frequently to be found three, and occasionally four. (See figure 1, plate II; illustrating three eggs as taken from a slit in a corn leaf. From a photomicrograph; much enlarged.) The young, when ready to leave the egg effect a rupture at the top and gradually work their way out. This escape requires from twenty minutes to a half-hour. Upon escaping from the egg, the nymph moves around slowly for an hour or so, in the vicinity of its birth. Usually by the end of the first twenty-four hours, the nymph has taken sufficient food that it may be detected by its color, in the alimentary canal. Considerable agility is soon acquired and by the time the third stage is reached, they are able to jump some distance. While in the earlier stages, they prefer the leaf-sheaths or a protected part of the leaf, as where one leaf overlaps another. In such places they may frequently be found hidden away in great numbers, when the plant is apparently free from them. In the latter stages, as from the fourth on, they occur somewhat promiscuously on the leaves and stem of the plant. The corn Delphax is quite active in its latter stages, jumping with agility when disturbed. Adults usually jump in preference to taking flight, when molested. On the plant, the older nymphs and adults move readily sidewise, and their attempts to sidle around a stem or leaf out of sight, is somewhat grotesque.

Mr. Ashmead has found that the life cycle occupies about one month during July, August and September. My own observations indicate that the life cycle may occupy considerably more time than this, somewhat later in the season. On November 10th breeding experiments were started with this insect in the Station propagating house where the temperature surrounding was kept at about 60 degrees F., or somewhat higher.

A considerable number of adults were confined on young corn plants, and egg depositing began in a few hours. By the end of two days a considerable number of eggs had been deposited along the mid-ribs of leaves; the adults were now removed from the plants, which were carefully protected from infestation from the outside. By December 6th several young had hatched, probably from eggs first deposited. For several days succeeding, young continued to appear. December 14th several moulted for the first time; by the 19th, several had moulted for the second time, and on the 28th many had moulted again, and hence were in the fourth stage. This stage continued until January 7th, when the last nymphal stage was attained by moulting for the fourth time. On January 18th the adult stage was reached, by moulting for the fifth time.

As will be observed from the above, the egg state continued for seventeen days; the first nymphal state for eight days the second five, the third nine, the fourth ten and the fifth for eleven days, thus making the life cycle sixty days.

This difference in time of life cycle as compared with the summer broods is no doubt due to the lower temperature, and well illustrates the effect of change of temperature on the development of insects.

There is an interesting variation in the adult, in that there is a short winged or brachypterous form, as has been pointed out by Mr. Ashmead. The hind pair of wings in this form seem to be wanting, and the first pair are very much reduced. (See figure 6, plate II, showing above, a normal fore-wing from the right side; below, a reduced fore-wing from the right side of the brachypterous form. From a photomicrograph, much enlarged.) Asi from this reduction of wings, the short winged form seems to be essentially the same as the normal form. Either sex may be brachypterous, and mating was frequently observed between the two forms. In the case of insects bred out in the forcing house during December and January, the proportion of short winged forms was considerably greater than that of the long winged forms. For instance, under one jar twenty adults were bred out, and fourteen of these were of the brachypterous form. This proportion seems to be about reversed during the summer months, the long winged form being much more abundant. Possibly the somewhat lower temperature under which the specimens in the forcing house were bred, may have some relation to the question of the cause of this dimorphism.

DESCRIPTION OF THE DIFFERENT STAGES.

Egg—Length .75 m m. (.029 in.); width at center .18 m m. (.007 in.); shape oblong, curved, tapering slightly to apical end. Color clear white, in fresh eggs, transparent; in advanced stages embryo plainly visible; eye spots quite pronounced, at an early stage reddish.

Apical end of egg is deposited about even with surface of leaf; slit cemented over; eggs, when in leaf, deposited on upper side. (See figure 1, plate II.)

First Nymphal Stage—Length .916 m m. (.035 in.); width of head .2 m m.; width of thorax .283 m m. (.011 in.); color, body whitish, slightly tinged with yellow, legs and antennae lighter; body containing numerous reddish granules. Eyes, reddish. Shape, oblong, depressed. Antennae three jointed. Basal joint very short, broad, somewhat disk shaped. Second about four times length of first, pear shaped; third somewhat urn shaped, with very narrow attachment at base. This joint is composed of

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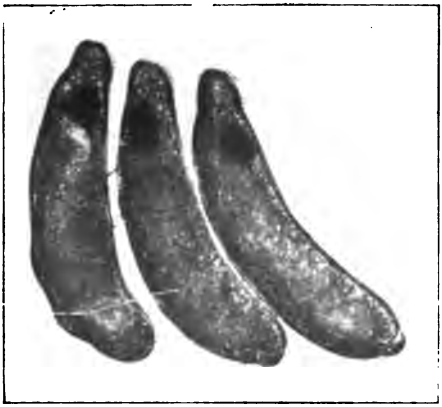
EXLPANATION OF PLATE II.

Delphax maidis.—1, eggs; figures 2, 3 and 4 nymphs, first, second and fourth stages; 5, adult; 6, long and short wings of adults. All from photomicrographs greatly enlarged. Figures 5 and 6 less enlarged than others.

PLATE II.



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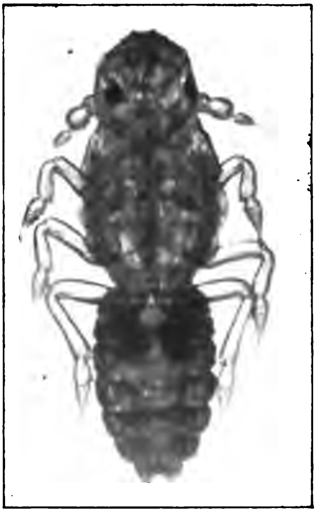

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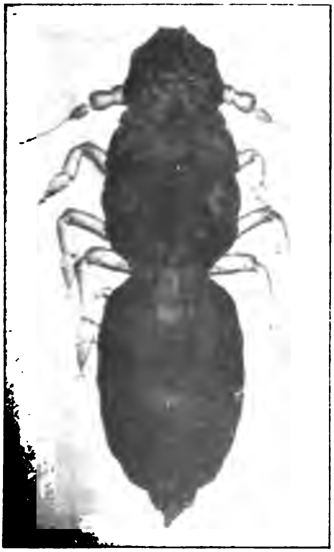

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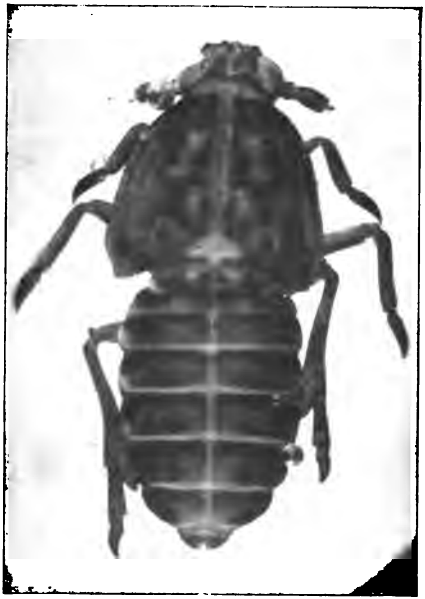

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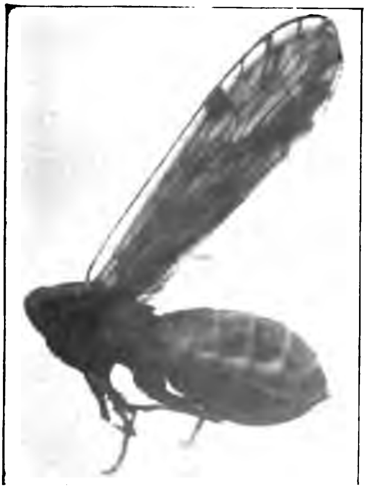

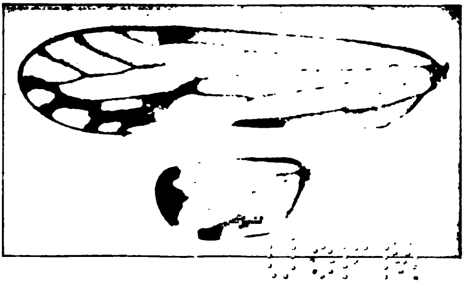

Fig. 6.

two distinct parts, the urn shaped basal portion, and a long filiform prolongation, somewhat longer than the remainder of antennae. This prolongation of the third joint is marked with numerous rings, some of which appear to divide it into regular joints. The urn shaped base is about two-thirds length of second segment, and about one-third its diameter. At the distal end of basal part of third joint, are numerous spines arranged more or less circularly, and curved inwards. Rostrum three-jointed; basal joint short, about one-third length of second. Second and third sub-equal in length; third tipped with brownish black. Legs, well developed; coxae quite long; tarsi stout, conical, two jointed; the joints of first and second tarsi rather indistinct, indicated by pronounced circular construction. On last tarsi, the joint is much more distinct; the proximal segment bears distally a circular row of short, broad-based spines, tipped with dark-brown, and a much larger stout spine. Tarsus terminated by two claws with a membraneous-like expansion. (See figure 2, plate II, from a photomicrograph greatly enlarged.)

Second Stage—Length 1.33 m m. (.051 in.); width of head .3 m m.; wdth of thorax .46 m m. (.017 in.) Color whitish, abdomen somewhat yellow; eyes reddish, as in stage I. Shape as in state I. Abdomen proportionately larger.; head proportionately smaller than in first stage; the dorsum of thorax is marked by six quadrilateral plates. (See figure 3, plate II.)

Third Stage—Length 2 m m. (.078 in.); width of head .366 m m.; width of thorax .666 m m. (.025 in.). Color light yellow; dorsally, a general clouding with dusky, deeper on sides of abdomen. Legs and antennae lighter. Eyes deep red, much deeper centrally. The quadrilateral plates of the mesothorax and metathorax prolonged slightly on outer corners of caudal margin, thus indicating the beginning of wing-pads. Legs as in previous stages, except that in the hind pair the large spur on tibial joint is movable, and proportionately larger. The spur bears on its inner margin, three or four short stout spines.

Fourth Stage—Length 2.86 m m. (.111 in.); width of head .6 m m.; width of thorax 1 m m. (.039 in.). General color, yellow, clouded dorsally, deepest on sides of abdomen. Eyes reddish black. Shape essentially as in previous stage. Wing pads considerably elongated reaching middle of first abdominal segment. First pair of wing pads not quite reaching tip of second. The suture on tarsi of first and second pair of legs, much more distinct and nearer tibia than in first stage. The last tarsus is three jointed; proximal joint with a row of short stout spines on its inner margin. On distal portion of second tarsal joint are one, two or three stout spines like those on proximal joint. (See figure 4, plate II.)

FIFTH STAGE—Length 3.23 m m. (.095 in.); width of head .566 m m.; width of thorax 1.166 m m. (.045 in.). Color, essentially as in previous stage. Second pair of wing pads reaching third abdominal segment; first not quite reaching tip of second.

THE ADULT—Female, length 2 and 3-5 mm. (.1 in.); wing expanse 7 m m. (.27 in.). Greenish to brownish yellow in color, with cloudings of smoky black on apex of first and apical half of second antennal joint, clypeus, frons, and coxae. The abdomen is more or less clouded with smoky, and with lateral stripes of yellowish. Caudal margin of segments also yellowish. Legs pale, femora brownish; on apical end of posterior tibia several black tipped spines and a large movable spur; tarsi three jointed. Beak evidently but two jointed, extending beyond the middle coxae. Front wings are pale greenish brown, sub-hyaline, with apical portion more or less clouded with fuliginous. (See figure 5, plate II.)

SHORT WINGED FORM—Differs from the normal form in the reduced wings, in being slightly longer (3 m m.), in possessing a somewhat broader and more depressed abdomen. The aborted front wing is shown in figure 6, plate II.

TREATMENT.

This insect will not yield readily to ordinary insecticides. Being sucking insects, arsenical poisons would not of course, be of value against them. Kerosene emulsion would be valuable no doubt destroying those reached, but as will be remembered, the nymphs during the earlier stages live down in the leaf sheaths, where they would quite escape spraying. The numerous eggs also, in the leaf tissue, would probably not be effected by spraying. In view of these facts, it would probably be best to quite destroy infested plants by burning them. In a field of corn, so badly infested as to become stunted and yellow, it would no doubt be more profitable to destroy the crop, and plant the land to something else not attacked by the insects. The exact natural food of the insect has not been recorded. Prof. Morgan, however, mentions having swept it from various grasses. Judging from the habits of its near relatives, its food is probably limited to the grasses. It would seem safe to replant an infested field to almost any crop not belonging to the Gramineae.

The Canna Leaf-Roller. *

(*Hydrocampa cannalis*, Fernald, MSS.)

For the past three years the cannas (Canna Indica) in the neighborhood of Lake City have been badly infested with a leaf-rolling larva which by eating out the parenchyma from the inner (upper) side of the leaves has occasioned very serious damage to these plants. Leaves infested soon become so badly eaten that they die, becoming brown and ragged, thus changing them from beautiful ornamentals to unsightly objects. The insect doubtless occurs throughout the State. Those having beds or terraces of cannas which have been dying, or browning, would do well to look for this insect in connection with the trouble, and follow the treatment herein advised if it is observed to be present.

Leaves may either be rolled up from one side, by the larvae or, as is more frequently the case, younger leaves are fastened, before they have unrolled to any extent. The caterpillars feed within the rolled up leaves eating out the soft tissue to the epidermis of the lower surface. Rarely is the epidermis of the lower surface of the leaf eaten into, it being left usually quite intact. In the case of younger unrolled leaves, the margin of the outer leaf is firmly fastened to the roll by short silken threads. On the interior leaves of the roll the larvae feed, usually quite consuming the parenchymatous tissue within. In other cases, fully expanded leaves are rolled up parallel to the mid-rib. This is done much after the usual manner of leaf rolling larvae by spinning a thread from the margin of the leaf to a point farther in toward the mid-rib. Several of these cords are spun along the margin of the leaf and by their subsequent contraction, the margin is pulled over, and finally touches the leaf, thus forming a tube within which the larvae feed. When the parenchyma within this tube is eaten out, the leaf is rolled again, the larva coming out along the lateral margin of the tube, and spinning threads from the tube to points yet nearer the midrib. In this way a large canna leaf may be quite rolled up. (See figure 7, plate II.) Usually but one or two larvae occupy a single leaf. However, as many as five or six were found in a few cases.

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* I am under obligations to Dr. C. H Fernald for the determination of this insect, which he has found to be new to science; Dr Fernald will doubtless publish a description of the insect in the near future.

LIFE HISTORY NOTES.

In order that the insect might be studied during its entire life cycle, about two dozen pupae were collected and brought to the laboratory, and placed in a breeding cage, October 16, 1896. Moths appeared October 23th, 24th and 25th. Eggs were found on the 24th in considerable abundance fastened to the glass doors and elsewhere, of the case. The eggs were placed in patches of six to fifteen, firmly fastened, and with but little show of order in their arrangement some overlapping, some directly above others. The embryo could plainly be detected by noon of the 27th. The development from this date seemed quite rapid. By October 31st nearly all of the eggs had hatched. An hour or two after hatching the larvae began looking around for food. Specimens of just hatched larvae were placed on fresh canna leaves, and after crawling around for a few minutes began to eat greedily of the leaf. By the end of the next twenty-four hours, many had eaten down to the lower epidermis, and had then mined out an inch, or an inch and a quarter, between the lower and upper surfaces of the leaf. These could be readily observed with a hand lense, feeding within. The mines behind the larvae soon became quite filled with brownish colored excrement. As these larvae grew, their tunnels became too small for them and they were forced to leave them, eating a circular hole to the upper surface of the leaf. From this time until they began rolling the leaves, the larvae fed more or less gregariously, eating out patches of parenchyma to the lower epidermis. In some cases, the larvae crawled to the base of the leaf, and fed between the growing stem and the petiole. On November 7th, the first leaf-rolling tendency was observed. The margins of the leaf were pulled over somewhat by silken cords thus forming a protection. From this date leaves were rolled more or less completely, and young and unfolded leaves were fastened so that they did not further unroll.

Before pupating the larva usually fastens some portion of the leaf tightly around itself, and spins within this a slight lining of silk. The first pupa was observed November 25th, quite firmly fastened to the silken lining on the inside of its case, by the eight hooked spines on the caudal end of the abdomen. In the course of two or three days, many more larvae had pupated. From this it is observed that the life cycle in this instance is approximately forty days. Adults emerged from several of these pupae, during several days of warm weather during the latter part of December. Many adults, however, did not appear until the first of March, and it would seem that the winter may be passed in the pupal condition.

A study of the insect in the field also indicates that the winter is passed in the pupa state. However, a few larvae were observed snugly fastened up, which probably passed the winter in that condition. By the latter part of February, the moths were quite numerous among dried canna leaves on the terraces. By the tenth of March they were much more abundant, and as the cannas were now sprouting up through the ground, eggs were doubtless deposited about that date. On March 19th, the young leaves of the cannas were observed to be badly infested with larvae, many leaves having been already rolled and fastened together. By April 3rd many of the larvae had pupated within the rolled up leaves, and in the course of ten or twelve days, the adults from these began to appear. In this instance the life cycle was approximately thirty-five days. The difference in time required for the life cycle in the fall and spring broods is probably due to more favorable weather during the spring. During midsummer, it is not improbable that life cycle is somewhat less than in the case of the first spring brood, possibly as short as twenty-eight or thirty days. Succeeding the first brood, these do not occur as distinct broods, but soon become quite confused so that the insect in all stages may frequently be found at the same time.

During the present season ('97) the insect has not been quite so abundant as last, but it has still been sufficiently abundant to be a serious pest. The adults are rather shy, and if disturbed fly a short distance and usually alight on the under side of the leaf, as much in the shade as possible. Not infrequently they alight on the dead leaves with which they agree so closely in color that they become exceedingly difficult to detect. The moths are probably nocturnal, as in no case were they observed to fly voluntarily during the day.

DESCRIPTION.

EGG—Size, .85x.925 m m. (.033x.036 in.). Slightly longer than broad; even outline, very flat. Deposited in patches of from six to fifteen (in breeding case) many overlapping others; firmly cemented by slightly opaque glistening substance. Color, clear whitish yellow, the embryo plainly visible within, at the proper stage. The surface is marked with numerous slightly raised lines forming small irregular polygons.

LARVA, FIRST STAGE—Length about 1.4 m m.(.546 in.); width across base of head .23 m m. (.008 in.); length of head .216 m m. (.— in.); width across third abdominal segment .166 m m. (.064 in.); shape of body, almost cylindrical, tapering gradually caudad from head. Head cordate, large in proportion to rest of body. Color, yellowish, somewhat transparent; head yellow; eyes brown. Mandibles well toothed, brownish black at tips. Antennae short, stubby, each having distally three or four finger like processes, and a long terminal seta. Thoracic legs well developed, terminating in a hook, and a blade like structure which acting together may form a clasper. Pro-legs normal; each with a single row of rather stout, brownish colored hooks; anal pro-legs present.

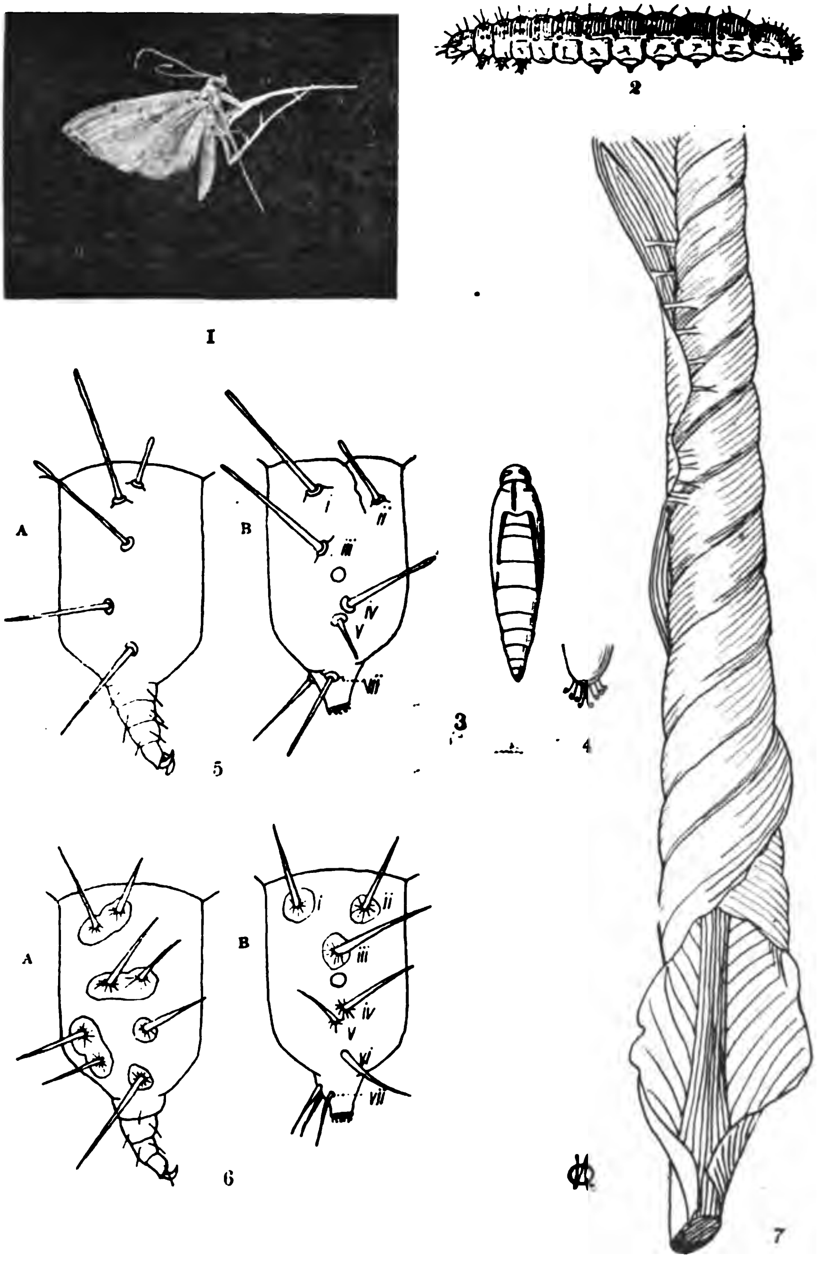
The tubercles are arranged as illustrated in the diagram, figure 5, plate III: a, the third thoracic segment; b, the third abdominal segment. Tubercle I of the third thoracic segment, has the normal sub-dorsal position, and bears a single, well developed blunt ended seta. Tubercle II is less developed than tubercle I, and its seta is shorter. It is situated slightly ventrad of a line drawn directly caudad of number I. Tubercle III is similar to number I in development; its seta is also of about the same length. It is situated a short distance dorso-cephalad of the spiracle. Tubercle IV is ventrad, and slightly caudad of the spiracle; it bears a well developed and blunt ended seta. Tubercle V is much reduced, and somewhat closely approximated to tubercle IV. Its seta is reduced and sharp pointed on the end. It is slightly cephalad of a line directly ventrad from tubercle IV. Tubercle VI seems to be wanting at this stage. Tubercle VII is represented by two quite well developed tubercles and setae. Tubercle VIII is near to the inner base of the pro-leg. It bears a short pointed seta.

LARVA, LAST STAGE—Length about 23 m m.(.897 in.); width of head at base 1 m m.(.039 in.); width across third abdominal segment 3 m m. (.117 in.). Shape of body, cylindrical, tapering somewhat cephalad and caudad. Head, cordate in shape. General color of larva, yellowish white; quite transparent, so much so that in a live specimen the pulsation of the dorsal tube may be easily observed. A greenish appearance is given to the caterpillar from the green food within the alimentary canal. Head yellow; clypeus, yellowish brown; tips of mandibles, brownish-black. Antennae as in stage I, except slightly elongated. Ocelli, five or six on each side. Thoracic legs well developed, terminating in short brownish claws. Abdominal pro-legs each supplied with a circle of stout brown hooks. Anal pro-legs with but the cephalic half of circle of hooks present.

Supra-spiracular tubercles surrounded by yellow corneous areas. In the thoracic region these areas may extend below the line of spiracles, (see figure). These areas have on the whole, a circular outline with slightly raised lines converging to the base of the tubercle. In the thoracic region, however, these areas show a tendency to coalesce, thus forming more or less irregular corneous areas. Numerous pigment spots occur in these corneous areas. Prothoracic shield well developed.

Tubercles of the third abdominal segment are much the same as in stage I, except that tubercle III has moved slightly caudad, and is now almost directly dorsad of the spiracle; IV and

PLATE III.



Hydrocampa cannalis.—1, adult (from photograph. enlarged about ⅓ diameter); 2, larva; 3, pupa; 4, caudal end of pupa. more enlarged; 5, enlargld segment of larva in first stage; a. third thoracic segment; b. third abdominal segment; 6, same as 5, bu in last larval stage; 7, canna leaf. as rolled by larva.

V are approximately the same. Tubercle VI is present at this stage, and is situated directly ventrad of tubercle IV, about equally distant from both IV and VII. Tubercle VII is composed of three somewhat reduced tubercles and setae; VIII is present in approximately the same position as in stage I, (see figure 6, plate III, A and B).

PUPA—Length 11.5 m m: (.448 in.); width across the thorax 2.75 m m. (.107 in.); color of thorax, head and wings, chocolate brown; abdomen somewhat lighter. By the use of a lense the caudal end of the pupa is seen to be rounded, bearing eight rather stout dark brown hairs, curved on the end into hooks, forming an organ for holding the pupa to the silken threads which the larva spins within the leaf case (see figures 3 and 4, plate III).

ADULT—Female, wing expanse about 25 m m. (.975 in.); length of body 11 m m. (.429 in.); length of antennae 7 m m. Color, quite uniform light brown, varying in different specimens to lighter; lines of brownish black extend across both primaries and secondaries respectively one-third and two-thirds the length of the wing distant from its base. A small angular patch of white is found near the distal portion of the discal cell of the primaries. (See figure 1, plate III, which illustrates the moth about two-thirds enlarged; from a photograph.)

TREATMENT.

The canna leaf-roller can doubtless be best controlled by carefully cleaning off and burning the dead plants and trash from the beds during the winter season. By this procedure, most of the pupae and larvae, which pass the winter in these leaves and trash will be destroyed. The rolled up leaves should be watched for in the spring, and cut off and burned. Figure 7 illustrates the appearance of a leaf rolled up by these larvae.

ACKNOWLEDGMENTS.

I am under obligations to Prof. P. H. Rolfs for looking over my manuscript, and to my wife, Nellie M. Quaintance, for the drawings in plate III.

BULLETIN 46. JULY, 1898.

Florida Agricultural Experiment Station.

The Strawberry Thrips
— AND –
.......The Onion Thrips.

By A. L. QUAINTANCE.

The Bulletins of this Station will be sent Free to any Address in Florida upon Application to the Director of the Experiment Station, Lake City, Florida.

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SUMMARY.

I. Thrips tritici:

(1) *Thrips tritici* has been quite destructive to strawberry and other crops, in Florida, during the spring season of the past two years. The damage to strawberries consists in chafing the stigmas and ovaries, thus causing the blossom to turn brown (blight) and eventually dry up. The damage will be greatest during times of drouth. The foliage of the English pea, LeConte pear and Kelsey plum have suffered severely from the ravages of this insect. Various flowers are blighted, particularly certain varieties of roses, which are frequently rendered quite worthless.

(2) The life cycle of *Thrips tritici* is quite short, requiring but twelve days. Eggs are deposited in the tissues of infested plants, and hatch in three days. The larval state lasts for about five days, during which time the insect makes two molts, the second when entering the nymph stage. The nymph stage continues for about four days, during which time they take no food, rarely move to any extent, but remain hidden away.

(3) This insect may be successfully controlled by the use of the Rose Leaf Insecticide, at the rate of one pint to six gallons of water. Whale oil soap, and kerosene emulsion may also be used with success.

II. Thrips tabaci:

(1) This insect is destructive to many plants. In Florida its ravages have been confined principally to onions, cauliflower and cabbage. The leaves are chafed, which in the case of the onion, causes the tops to whiten and dry out. In the case of cabbage and cauliflower, the infested leaves become browned and scorched in appearance, particularly noticeable on the under side; leaves thus affected are of but little functional value.

(2) The life cycle of *Thrips tabaci* is somewhat longer than that of *Thrips tritici*, requiring about sixteen days for completion. The egg state lasts about four days; the larval stage for about eight days, and the nymph stage for four days. The insect goes through three molts during its life cycle.

(3) This species of thrips can be successfully controlled by the use of the Rose Leaf Insecticide, whale oil soap, or kerosene emulsion. They should all be used somewhat stronger than for *Thrips tritici* however, as the insect under discussion seems better able to stand them.

GENERAL REMARKS.

The name "Thrips" is applied rather indiscriminately to the insects belonging to the order Thysanoptera (Physopoda), much as we speak of a beetle (Coleoptera), or a fly (Diptera). The members of the order Thysanoptera may be characterized as follows: There are two pairs of wings, each pair somewhat similar in form, long, narrow and membranous, having but few or no veins, and fringed with long hairs. When at rest, the wings are placed horizontally along the back. The mouth parts are quite different from those of any other order of insects, being intermediate between those of biting and sucking insects. The mandibles are reduced to bristle-like structures, while the maxillae are flat, triangular, and bear palpi. Labial palpi also, are present. The tarsi of thrips are composed of two joints, without claws, each being terminated by a bladder-like structure.

The members of this order are quite small, rarely exceeding 3mm. in length; they are usually quite active, some flying readily or leaping when disturbed, which, with their minute size has calculated somewhat to keep the general public in ignorance of their existence. All, however, are probably familiar with the small, active insects frequently to be found in roses and other flowers. This is a medium-sized thrips and will serve to illustrate the group.

According to Dr. Heinrich Uzel, in his recent "Monographie der Ordnung Thysanoptera" the order embraces 135 species, which are distributed in thirty-five genera. Nearly all of these are European species, but few having been described from the United States.

The food of thrips is quite varied; some are carnivorous, but many feed upon vegetable substances. The vegetable feeders attack various portions of plants, as flowers, bark and leaves, and in some cases they become of economic importance. It is an interesting question as to how these insects secure foodas their mouth parts are plainly not adapted for chewing, and but little better for sucking. Nevertheless it seems probable that in many cases they are used as a suction apparatus, as in *Thrips tritici*. In other cases, as with *Thrips tabaci*, particles of leaf tissue are torn or rasped off, and swallowed. The writer has frequently seen such particles cast out with the excrement.

Probably the two species herein considered are to be regarded as of the most economic importance of the Thysanoptera, in the United States; although there are several species that cause more or less damage at times, yet the records do not show them to be so severe nor as common as *Thrips tritici* and *Thrips tabaci*. It should be noted that the so-called Thrips (*Typhlocyba vitifex*, Fitch, and other species) of the grape vine, are not Thysanoptera at all, but belong to the Jassidae, of the order Hemiptera. The misuse of the word thrips in this connection has occasioned considerable confusion.

THRIPS TRITICI, OSBORN (FITCH).

This insect was first described in 1856 by Dr. Asa Fitch, State Entomologist of N. Y. from specimens received from Wisconsin. The common name of wheat thrips was given to it from the fact that it was at that time very injurious to wheat. Dr. Fitch says, *"Although this species, like many others in this order, occurs upon the flowers of the different plants, it is upon wheat, in all probability, that it will be oftenest noticed, and to which it will prove most injurious. It may therefore appropriately be named the Wheat thrips, *Thrips tritici.*"

From 1856 until 1880 this insect seems not to have attracted much attention; beginning with 1880, however, occasional references have been made to it, as a study of the bibliography will show. At various times it seems to have become unusually abundant and destructive where conditions have been favorable for its development. The insect enjoys a wide distribution over the United States and Canada, infesting the blossoms and foliage of various plants.

In Florida we have this insect with us throughout almost the entire year. In the latitude of Lake City there are short periods of cold weather, during which the thrips doubtless hide away for protection. But in Southern Florida they may be found more or less abundant at almost any time of the year.

I have not been able to find any definite records of their occurence in unusual and destructive numbers in Florida, previous to last year, except, perhaps, in Ashmead's Orange Insects, 1880, and Hubbard's Orange Insects, 1885, where mention of thrips is made as very abundant in orange blossoms, and means suggested for their destruction. But from these reports, nothing very definite is gained as to their work, extent of damage, and time of occurence. Certain it is, however, that during March, April and May, of the past two years ('97 and '98), thrips have occurred in myriads in various parts of Florida, and in certain strawberry growing sections they have caused a reduction of the usual yield of strawberries quite one-third. The strawberry crop in Florida, particularly the early crop, is quite valuable, from the remunerative prices it brings in northern markets, hence the loss caused by these insects becomes very great.

The past two springs have been unusually dry, which condition seems to have been very favorable for the insects, and on the other hand, has been unfavorable for plants, rendering them less able to resist the effects of the insects. During March, April and May of 1897, the rainfall for each respective month at Lake City was 3.09 in., 5 in. and .66 in. The departure from the normal was respectively, 2.50 in., 1.87 in. and 3.43 in. There was thus a total rainfall of 8.75 in., which is 8.80 in. less than the usual amount of rain for that period. During the same months of 1898, the drouth at Lake City was somewhat greater than during '97, while in many parts of the State there was practically no rain at all. During March, April and May of '98 the rainfall per month was respectively, 1.60 in., 1.94 in. and 1.47 in., making the total at 5.01 in., a departure of approximately 11 in. from the normal. But aside from the amount of precipitation, the nature of the rainfall has an important influence on the abundance of thrips. A heavy dashing rain destroys great numbers of both old and young, whereas a gentle, but prolonged rain causes but little destruction to them. Frequent examinations, several hours after heavy rains, of plants that had been previously badly infested, showed that but comparatively few thrips survived, at least in the blossoms. But from the fact that the eggs are not thus destroyed, and from the fact that the life cycle is very short, the thrips may soon become quite abundant again. A good dashing rain every two weeks, would doubtless keep them so in check, that their injuries would not be noticeable.

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*Noxious Insects of New York. I and II. p. 307.

Thus far thrips have been unusually abundant only in the spring, beginning with the advent of warm weather and blossoms, and disappearing with the approach of the rainy season in June, or somewhat earlier.

THRIPS IN 1897.

The principal injury caused by thrips in 1897 was confined to the strawberry. They began blighting these, in some localities, as early as March 27th. At Lake City they were not particularly destructive until about April 10th, when in several fields the bloom was observed to be becoming badly blighted. In this locality, those fields that are on low and moist soil suffered much the worst. For three or four weeks, some such fields did not yield sufficient fruit to make it profitable to gather it, the clusters of bloom browning and dying, soon after the petals were well expanded. (See Fig. 1.)

Although there seemed to be little if any doubt but that the thrips were entirely responsible for the damage to the strawberry, yet the importance of proving this beyond a possible doubt, before beginning experiments looking towards stopping the trouble, made it desirable at the outset, that experiments be conducted in this connection, and also to determine the exact manner in which the trouble was done, and of what it consisted. Hence, several Newnan plants were brought to the laboratory, and all blooms but unopened buds were removed. A number of these buds were then inclosed in large glass tubes, plugged loosely on either end with cotton. As soon as these buds had opened, some were supplied with thrips; others were kept uninfested, as checks.

The thrips at once attacked the stigmas and distal portion of the styles, chafing and apparently puncturing them. In the course of ten or twelve hours many of the stigmas began to blacken, and twenty-four hours from this time, nearly all of the stigmas had blackened, and the styles were blackening half way down to the ovaries, and wilting perceptibly. In the course of another day, the styles had blackened to the ovaries and were plainly drying up. The ovaries were also attacked and blackened considerably from the chafing of the thrips. By another day the entire young fruit, receptacle, and ovaries were black and dead, and the blackening in some cases had extended some ways down the fruit stalk.

It should be noted that other parts of the flower were attacked besides the pistil. The petals were sparingly attacked, particularly at their bases; also the stamens, principally the filaments. But as a whole, the preference was decidedly for the stigmas and styles, probably on account of the sweetish substance secreted by the stigmas, to aid in the germination of the pollen.

The blossoms in tubes not inoculated with thrips, did not show this blackening and drying up. In several instances where the stigmas were pollinated, fruit set normally.

The results seemed conclusive, yet the same experiment was made again in the laboratory, and also in the field. In the field, after all open and infested flowers had been removed from a plant, it was covered with a lantern globe, by pressing bottom end into the soil, and fastening a strip of cheese cloth over the top. Ten plants were thus prepared. After several buds had opened into flowers, five plants were supplied with thrips, and five were kept as checks. This experiment confirmed the experiments made in the laboratory, and left no doubt that the thrips were responsible for the blackening and wilting of the fruit.

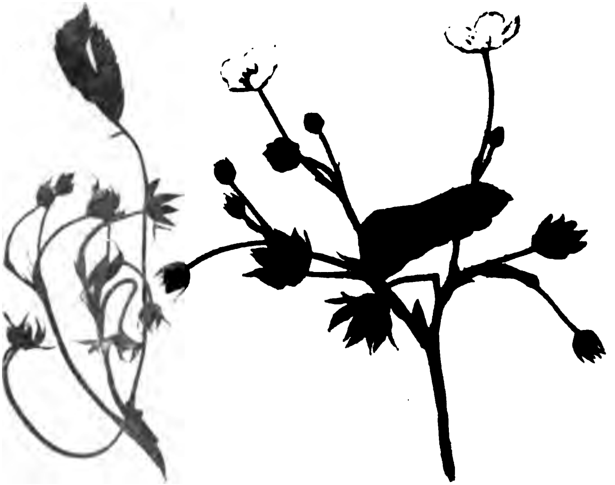

Fig. 1.—Illustrating on the right, a healthy flower cluster; on the left, one that has been destroyed by thrips. From a photograph.

The injurious effects of these insects seems to be to a considerable extent in preventing the fertilization of the ovules. Since the stigmas are attacked, and decay soon sets in, the normal fertilization of the ovules is greatly retarded, if not entirely prevented.

EXPERIMENTS WITH INSECTICIDES IN 1897.

Not much progress was made in the study of the life history of the insect during 1897. A study of this insect is beset with unusual difficulties, from its small size and exceeding agility. Enough, however, was learned to indicate the most hopeful line of treatment. Eleven different insecticides were tried, the results of which are herewith given, as taken from Bulletin 42, of this station.

Sulphur Spray.—Eight rows of badly infested plants were sprayed with sulphur spray. Three rows were left unsprayed as checks. Formula of sulphur spray used is as follows:

Flowers of Sulphur	3 pounds
Caustic Soda	2 pounds
Water	1-3 gallon

To this was added two gallons of water, the whole making a stock solution. The stock solution was used at the rate of one and one-half pints to twelve gallons of water, and applied to all parts of the plant with a barrel pump sprayer.

Immediately after spraying the bloom was carefully examined. A few thrips were observed to have been killed. Many seemed distressed, but the majority were not so severely injured but that by the time the insecticide had dried from the blooms, they were to all appearances about as lively as ever. The sprayed rows were examined again the next morning when the thrips were found as abundant as in the untreated check rows.

Flowers of Sulphur.—Four rows were thoroughly dusted with flowers of sulphur to determine its value as a repellant. Two rows were left as checks. No difference could be detected in the abundance of thrips in the treated and untreated rows.

Pyrethrum Powder.—Pure pyrethrum powder was dusted thoroughly on three rows, with a Leggett powder gun. Two rows were left as checks. The pyrethrum seemed to be of no appreciable value against the thrips. They were observed to feed readily amongst the powder adhering to the bloom.

Pyrethrum in Water.—Pyrethrum powder suspended in water was tried at the rate of one-fourth pound pyrethrum to six gallons of water. This proved to be of but little if any value.

Pyrethrum Decoction.—One-fourth pound of pyrethrum powder was steeped for an hour, the water breaking into a boil a few times. This was diluted with eleven gallons of water and applied with a knapsack pump. Two rows were sprayed, one kept as a check. Examination immediately after spraying showed that a small proportion had been killed, and others were more or less distressed. Many thrips had run out on the petals and sepals, from which the solution soon dried and the thrips seemed to be unharmed. The next day no difference could be detected in the relative abundance of thrips in the treated and untreated rows. Doubled the strength of pyrethrum. Results, some improvement on above.

Tobacco Dust.—Tobacco dust was thoroughly sprinkled over and worked among the leaves of one row of plants. One row was kept as check. No difference in the number of insects in the two rows could be detected, when examined at different intervals.

Tobacco Decoction.—One pound of tobacco stems and leaves were boiled for one-half hour in two gallons of water. This was strained, and diluted with four gallons of water and applied to four rows with knapsack sprayer. Two rows were kept as check. Immediately after spraying, examination showed this insecticide was particularly disagreeable to the thrips. A small proportion were killed or evidently dying. Most of the adults had left the flowers entirely. Examination the next day showed that the sprayed plants were much freer from thrips than checks.

Rose Leaf Insecticide.—This is an insecticide manufactured by the Louisville Spirit Cured Tobacco Co., Louisville, Ky. It is claimed by the manufacturers that it is an extract of tobacco, of a uniform strength of nicotine. It should be noted that in a decoction made by boiling stems and leaves in water, the per cent. of nicotine is quite variable owing to the variation in quantity of this compound in different plants. This Rose Leaf was used at the rate of one pint to six gallons of water, and sprayed thoroughly on five rows with a knapsack sprayer. Two rows were reserved as checks. Examination immediately after spraying showed that the insecticide was much more effective than anything yet tried.

Quantities of thrips were dead evidently where the spray had first touched them. Others were dying or trying to work their way out of the insecticide, but were soon overcome. The per cent. of thrips destroyed by this insecticide would probably be near sixty-five or seventy. The action of the fluid seemed to be that of a strong irritant, and was sufficiently sticky to prevent the insect from escaping, after the spray had struck it.

Kerosene Emulsion.—This insecticide was made according to the following formula:

Soap (hard)	½ pound
Water	1 gallon
Kerosene	2 gallons

Two quarts of this stock solution were used to six gallons of water and applied with a knapsack sprayer to four rows of plants. The thrips were killed in considerable numbers. However, many that were thoroughly wet were observed to crawl out on the higher parts of the petals, and probably eventually recovered. Probably a stronger solution of the emulsion would be quite efficient, but the danger of tainting the fruit would exclude its use. And the application of the emulsion of the strength above indicated, would probably slightly taint the fruit.

Carbolic Acid in Water.—This was used at the rate of one ounce of acid, to six gallons of water. The acid used was comparatively pure, being derived from carbolic acid crystals. This mixture was applied with a knapsack sprayer to four rows of plants. two being kept as checks. The use of this insecticide resulted in killing a small proportion of thrips and drove many from the blooms. Examination the next day did not show any marked freedom of the sprayed plants from thrips, as compared with checks.

Whale Oil Soap.—This was used in the proportion of one-half pound of soap to six gallons of water. Applied thoroughly with barrel pump sprayer. Three rows were sprayed, one was kept as check. This insecticide seemed to be of some value

Some insects were killed, and the flowers were comparatively freed from thrips. Examination of sprayed rows the next day did not reveal much reduction of thrips as compared with their abundance in the checks.

From the results recorded above it will be observed that the "Rose Leaf Insecticide" gave much the most satisfactory results. Its superiority seems to be in its slight stickiness to hold sprayed insects from escaping, and in the rapidity with which it acts upon the insects.

It was early observed that the thrips passed readily from plant to plant, many leaving the flowers upon slight disturbance; and some that had been caught in the spray were able to crawl out from the blossoms and eventually escape to other parts of the field. This activity of the insects in passing to different plants explains somewhat their abundance in sprayed blooms, frequently in less than twenty-four hours after having been sprayed, and comparatively freed from the insects.

To get the best results, it seems necessary that an entire patch should be sprayed, and within as short a period of time as practicable. To test the value of such a procedure, the entire patch, save one row as check, upon which the foregoing experiments were conducted, was sprayed thoroughly with the "Rose Leaf Insecticide." The results obtained from this spraying indicated that much could be done to keep the thrips in check by its use when applied to the entire patch. The thrips were reduced throughout the patch at least one-half in numbers.

THRIPS IN 1898.

By the last day of March, thrips were very abundant in most flowers around Lake City, and by April 20th, they had become even more abundant, and had attacked the foliage of various plants, as LeConte pears, Kelsey plums, English peas, parsley and endive. Their ravages were most noticeable on the foliage of pear, plum and English pea. The tender leaves of the pear were so rasped, usually on the under side near the margin, that the epidermal and subjacent tissue was destroyed; from this it resulted that the leaf soon became much curled and misshapen, eventually browning and dying, where injured. (See Fig. 2.)

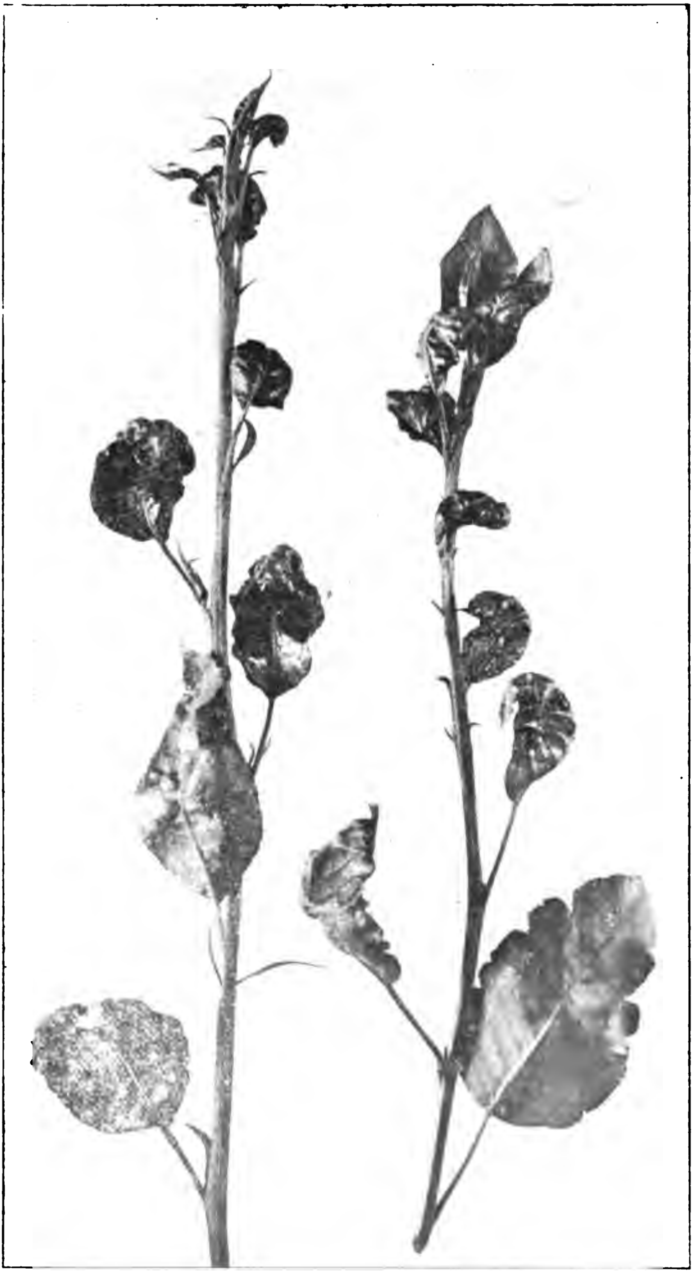

Fig. 2.—Two twigs of LeConte pear, illustrating the work of *Thrips tritici* on the tender foliage.

For about three weeks the young foliage of pear and Kelsey plum was thus attacked, greatly retarding their growth. The tender leaflets of the English pea were so severely attacked that in several fields the plants were kept quite at a stand-still for two or three weeks; they did not recover from the attack and yielded but a very small per cent of fruit. (See Fig. 3.)

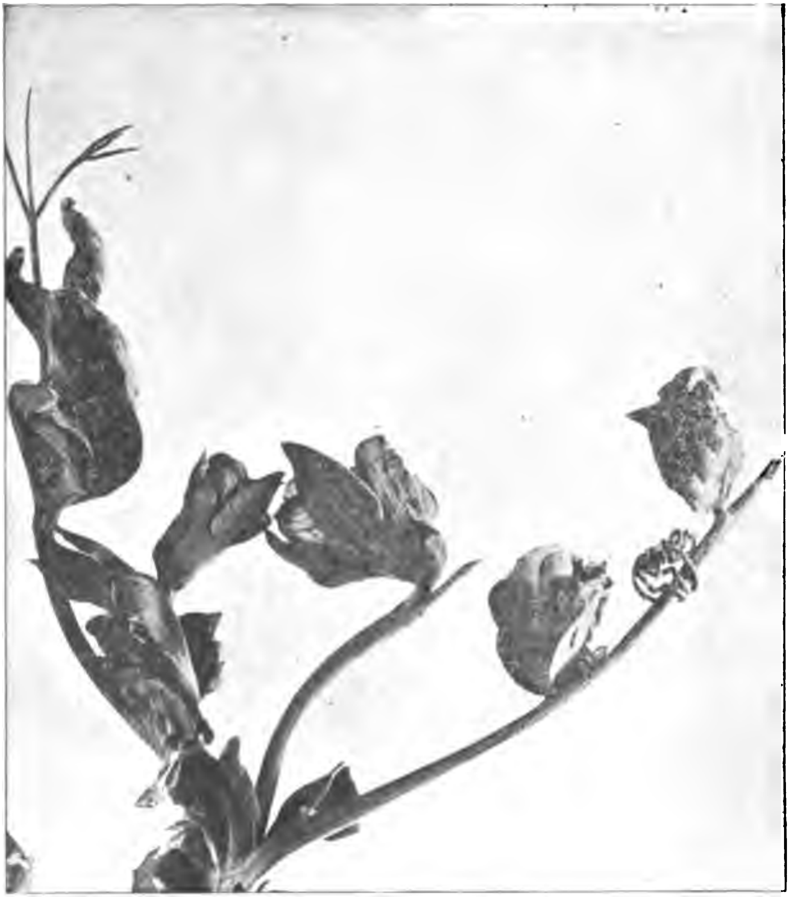

Fig. 3.—Illustrating the ravages of *Thrips tritici* on the tender foliage and flowers of the English pea.

The damage to the flowers of strawberries was not so severe as in '97, but blackberries, dewberries and roses probably suffered more.

In blackberries and dewberries, the damage probably consists in preventing the fertilization of the ovaries, as in the case of strawberries. There is a difference, however, to be noted, in the result, for in the dewberry and blackberry where the fleshy ovaries make up the fruit, a few ovaries may be left intact, and a small and inferior fruit may result, with a few normally developed ovaries. (See Fig. 4.) In the strawberry, where the fruit is made up of the receptacle, if the attack has been at all severe, the entire young fruit dries up.

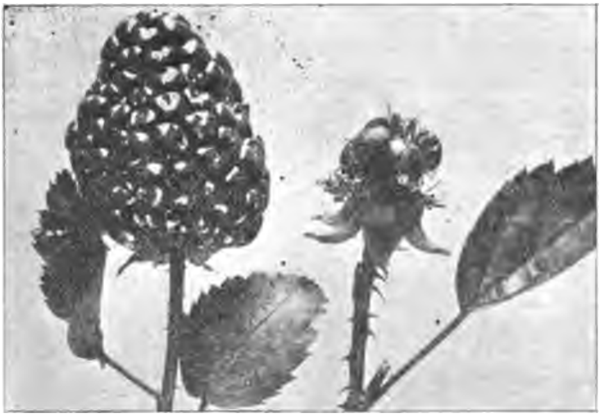

Fig. 4.—Illustrating on the left, a normal dewberry; on the right, one that is worthless, from the work of *Thrips tritici* on the stigma of the flowers.

The complaint of blighting of roses has been quite general. The petals are chafed, so that a rose soon blackens, and withers. A bud becomes infested as soon as it is sufficiently open to allow the entrance of the insects. In the course of eighteen to twenty hours it is usually so blackened as to be worthless.

LIFE HISTORY AND HABITS.

To determine the life history of *Thrips tritici*, a considerable number of adults were caught, divided about equally into three lots, and placed in three bottles. In each of the e bottles, two or three young bean pods were placed to furnish a place for oviposition, and also as food. At the end of twelve, eighteen and twenty-four hours respectively, the thrips were removed. In the course of about three days the young began to work their way out of the beans.

A just hatched thrips was carefully transferred to each of twelve small tubes, in which had been placed a small piece of rose petal. It was possible by this means, to keep close watch of each insect, and by supplying fresh food twice each day, five of the insects were bred into the adult condition, the others getting stuck to the tube by moisture, when very young. Four of the thrips that reached the adult condition were observed to go through three molts in all. The first molt occurs when the larva is about three days old; the second, at the end of the larval stage, when the nymph stage is entered; this occurs about five days after hatching. The nymph state lasts four days, when the final molt into the adult occurs.

From the above it is seen that the egg state lasts approximately three days, the first larval stage for three days, the second for two days, and the nymph stage four days, making a total of approximately twelve days for the life cycle. The same experiment was made again, about two weeks later, with practically the same results. The larval stage was found to vary somewhat, in one case it lasted for nearly seven days. The number of molts was found to be the same as previously recorded.

Oviposition was observed but once. In this case the thrips was on the outside of the calyx of a rose; the ovipositor was gradually worked down into the tissue, quite its length, and after a few seconds pause, the abdomen was seen to be contracting and expanding; five or six contractions occurred, when after a sudden movement of the antennae, the ovipositor was suddenly withdrawn, and the thrips ran on. Careful dissection of the calyx revealed the egg, its apex almost level with the epidermis.

In strawberries, eggs are placed mainly in the calyx, on the outside, where it surrounds the base of the large receptacle; as many as eight eggs have been found here, in a badly infested flower, by peeling back the epidermis, to which the eggs will remain attached. Many eggs are placed in the flower stalk, sometimes as far as three inches below the flower. In rare cases, eggs are placed in the bases of stamens, but never in the pistil, so far as I have observed. In the bean, eggs are deposited almost entirely in the flower stalk, the apex just even with the surface. In roses, eggs are placed in about the same position as in the strawberry, that is, in the calyx on the outside, and less usually in the flower stalk.

In hatching, the young thrips gradually works out until about four-fifths up, when the antennae and legs become separated from the body, and falling forward, it soon pulls itself free, the whole process requiring not more than one-half hour. As soon as hatched, the insect possesses considerable agility, and by three or four hours has taken sufficient food, that it may be detected in the alimentary canal, through the white semi-transparent body. In the course of eighteen hours they attain the characteristic bright orange-yellow color, though not yet so deep as in an older larva. In feeding gregariously, they make defensive use of the strong spines on the end of the abdomen, by striking right and left at the intruder, and usually securing a wider berth. Some eight or ten hours before molting into the nymph state, a thrips retires to a secluded place, where it remains very quiet, and unless molested, rarely moves. It gradually loses its bright yellow color, and eventually molts. The nymph stage is passed in a secluded place, frequently where the molt occurred. In tubes, the space between the small end of the cork and tube was a favorite place, or a dried petal was used. Unless disturbed, the nymph rarely moves; when disturbed, its movements are rather slow and uncertain, particularly in an older nymph. When this stage is first entered, the wing-pads are quite short, rarely reaching the caudal margin of the second abdominal segment, by the end of the first six or eight hours. At the end of about thirty-six hours, the pads are of full length, that is, reaching to near the end of the sixth abdominal segment. During the latter part of this stage, the skin and body seem to separate, somewhat, so that they may be clearly distinguished. When just molted, the adult is light yellowish, and does not attain its normal color until some hours later.

Adult thrips are quite agile, readily flying when disturbed, or at other times. A florist recently reported to me, that he had been very much annoyed by their crawling over his face and hands, and biting, as he sat by an open window in a lighted room at night. From personal experience, I know that they are capable of producing an unpleasant sensation of biting, when on the hands. They fly around to some extent, at least, through the day, as I have frequently observed them on my clothing, some distance from their food plants.

DESCRIPTION.

Egg.—Size, .25x.1mm (.009x.003 in.); clear whitish in color; oblong, curved in shape. (See Fig. 5, Plate I.)

LARVA, FIRST STAGE.—Length about .5mm, (.019 in.), width of thorax nearly .1mm. (.003 in.); body fusiform, gradually tapering caudad from fifth or sixth abdominal segment. Color, clear whitish; eyes, reddish. Antennae distinctly four jointed; basal joint, cylindrical, short; second somewhat urn-shaped, with distinct distal rim, about as long as broad; third joint conical, apex of cone united to second; fourth, fusiform, widest near basal fourth, quite as long as other three joints together. Joints two, three and four ringed; two and three rather obscurely, but on fourth joint the rings are quite pronounced, where, on distal part, they appear to divide the joint into short cylindrical segments. On the fourth joint the rings are minutely setate. Numerous large setae also are present on all joints, most numerous on fourth. Legs stout; hind femur about as long as tibia; tarsus one-jointed, terminating in claw-like fork; bladder-like expansion of adults apparently wanting. Abdomen composed of ten segments, marked dorsally with four longitudinal rows of setae, and a row on each side. All of these setae appear to be somewhat enlarged and rounded distally, except one pair on dorsum of last segment. On tenth segment these setae are quite long, being from two to four times longer than the others. (See Fig. 6, Plate I.)

PLATE I.

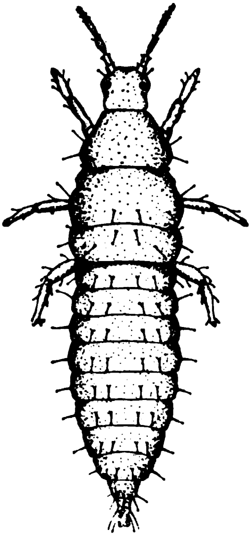

Fig. 7.

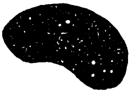

Fig. 5.

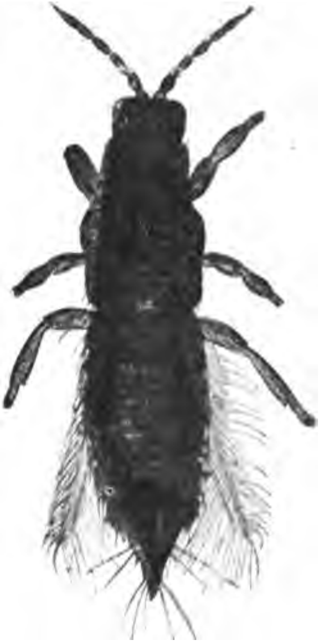

Fig. 9.

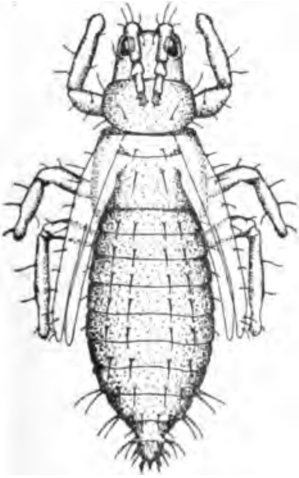

Fig. 8.

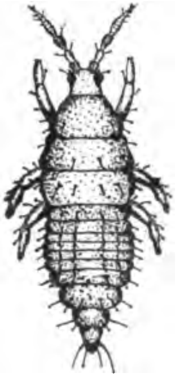

Fig. 6.

Thrips tritici.—5, egg; 6, larva, first stage; 7, mature larva, second stage; 8, nymph, or pupa; 9, adult female. All figures except 9, drawn by Mr. J P. Davies, under the author's direction. Fig. 9, from a photomicrograph. All much enlarged.

LARVA, SECOND STAGE.—Length about 1. mm. (.039 in.); width of thorax about .22 mm. (.008 in.); shape about as in Stage 1. Color of body, deep orange yellow; legs and antennae lighter; eyes reddish; antennae four-jointed as in first stage; basal joint short, cylindrical, about one-half as long as wide; second, sub-cylindrical somewhat longer than wide; third sub-conical about a third longer than wide; fourth about as long as proximal three together, fusiform, thickest about basal fourth. Joints three and four plainly ringed, the rings of fourth joint quite distinct and minutely setate as in first stage. Large setae also are present about as in Stage 1. Femur of hind legs about as long as tibia; tarsus one-jointed, somewhat forked distally, and bearing a mebraneous expansion. (See Fig. 7, Plate 1.)

NYMPH OR PUPA.

(1) YOUNG NYMPH.—The young nymph has a general resemblance to an adult larva in shape; in color it is much lighter, being light yellow, with legs, antennae and wing-pads still lighter. Eyes reddish.

In the antennae, legs and wing-pads the nymph skin appears somewhat as a sheath to these parts of the forming adult. The antennae are three or four jointed apparently, thick and clumsy. The basal joint is large, swollen, slightly longer than wide; the second is about twice as long as wide and somewhat constricted in middle. Third joint is about a third longer than second, gradually tapering distally to an obtuse end. When the nymph stage is first entered the antennae project cephalad, in normal position. In six or eight hours, however, they are laid back over the head and prothorax. The mouth parts are rudimentary, and are plainly not adapted to procuring food during this stage. In the hind legs, femur and tibia of about equal length; tarsus indistinctly one-jointed, very short and rounded distally. Wing-pads short, scarcely reaching caudal end of second abdominal segment, bearing one or two setae. Abdomen as in larva, with dorsal and lateral rows of setae, which, however, are acute. On the dorsum of ninth segment, near caudal margin, are four stubby, hook-like processes, curving cephalad, which appear to be the four modified setae for this region.

(2) MATURE NYMPH.—Length about 1 mm. (.039 in.); width of thorax about .22 mm. (.008); color light yellow; shape very similar to that of adult thrips. Nymph skin more or less separated from body of the adult within, particularly so in the legs, antennae, mouth parts, wing-pads and caudal end of abdomen. The wing-pads reach to about the sixth segment. The mature nymph is, of course, but the adult encased in the nymph skin. (See Fig. 8, Plate I.)

ADULT.—"Male, length, .75-.80 mm. (.029-.031 of an inch); width .20 mm. (.007 of an inch). Female, length, 1.10-1.20 mm. (.042-.046 of an inch); width .25 mm. (.009 of an inch). Color, yellow, thorax tinted with orange; antennae with dusky annulations. Head from above nearly square, eyes occupying anterior angles. Antennae approximate at base, joint two, apical half of four, and six, dusky; joints three and five dusky at apex, the antennae appearing annulated under low power of microscope. Head, thorax and abdomen with a few stiff hairs. Legs concolorous with body, all the tibiae with two spines at the distal end, distal joints of tarsi a little dusky, proximal joints of tarsi with two spines. Wings narrow, hyaline, fringes whitish; anterior wings have a costal fringe of shorter ciliae than posterior ones, and the ciliae are intermixed with shorter, stiffer, spiny hairs, which at base replace the fringe; two rows of blackish spines on the upper surface of wing corresponding with subcostal and mediam veins.

Posterior wings with no discal spines, ciliae of anterior edge shorter and more spiny than those of posterior. Both wings have rows of very minute hairs on the surface. The males are shorter and smaller than the females, with wings reaching beyond the tip of the abdomen."—H. Osborn. (See Fig. 9, Plate I.)

EXPERIMENTS WITH INSECTICIDES IN 1898.

It was intended to conduct extensive experiments against the thrips, to further perfect a remedy, and to find other and cheaper insecticides than those tried during '97. With the co-operation of Prof. Rolfs, a series of comparative tests of different insecticides was undertaken in the laboratory, as a preliminary to further field work. But before field work could be undertaken, the thrips had become so reduced in numbers that it did not seem profitable to undertake the work. The results of the laboratory tests are, however, given. As thrips were needed, a number of wide mouthed, four ounce bottles were taken to the field, and a considerable quantity of them collected in each, by picking off several blackberry blooms, shaking them in the bottle, and suddenly throwing out the flowers, after which it was corked. Thrips thus collected were brought to the laboratory, and as each was sprayed with a particular insecticide, another bottle of exactly same kind was tied to it, with the mouths together. The sprayed bottle was then closely wrapped in a black cloth, and the unsprayed bottles turned towards the light; by this means it was thought that thrips not destroyed would the sooner make their way to the unsprayed bottle, where, after separation of bottles, the per cent. of those alive and killed could be more easily determined.

The following substances were tried, being applied with a hand antomizer:

No. 1. Rose Leaf Insecticide.—(a) 1 part Rose Leaf to 32 parts water. Result, all dead, about 175.

(b) 1 part Rose Leaf to 64 parts water. Result, all dead, about 200.

No. 2. Whale Oil Soap, Anchor Brand.—(a) 1 part soap to 96 parts water. Result, all dead, about 200.

(b) 1 part soap to 192 parts water. Result, dead, about 120; alive, 5.

(c) 1 part soap to 240 parts water. Result, dead, 175; alive, 5

No. 3. Kerosene Emulsion.—Formula:

Soap (hard)	½ pound
Water	1 gallon
Kerosene	2 gallon

Diluted with 16 parts water. Result, all dead, about 50.

No. 4. Sulphur Spray.—Formula:

Flowers of Sulphur	3 pounds
Caustic soda	2 pounds
Water	1-3 gallon

To this was added 2 gallons of water, the whole making a stock solution, which was used at the rate of 1 part sulphur spray to 30 parts water. Result, dead, 64; alive, 39.

No. 5. Pyrethrum Powder.—About 75 were shaken up in a bottle with a half teaspoonful Pyrethrum. None were observed in second bottle, after a lapse of twenty-four hours.

No. 6. Pyrethrum Decoction.—One ounce powder to one quart water, boiled 20 minutes. Dead, 44; alive, 38.

No. 7. Tobacco Decoction.—(a) Tobacco stems and leaves, 2 ounces; 1 quart water, boiled one-half hour. Dead, 149; alive, 6.

(b) 1 part decoction to 32 parts water. Result, dead, 175; alive, 3.

No. 8. Tobacco Decoction and Syrup.—Tobacco, 2 ounces; water, 1 quart; syrup, 4 ounces. Result, dead, 80; alive, 30.

No. 9. Bluestone ($CuSO^4$).—Bluestone, 1 ounce; water, 8 ounces. Result, dead, 107; alive, 94.

No. 10. Salsoda (Na^2CO^3).—Salsoda, 1 ounce; water, 8 ounces. Result, dead, 127; alive, 49.

No. 11. Powell's Kerosene Emulsion.—1 pound to 10 gallons water. Result, dead, 74; alive, 70.

No. 12. Water.—Sprayed thoroughly with water. Result, dead, 3; alive, 75.

No. 13. Hammond's Thrip Juice, No. 2.—(a) Used at rate of 1 to 20 parts water. Result, all dead, about 175. (b) 1 to 40. Result, all dead, about 200.

No. 14. Potassium Sulphide (K^2S).—(a) 1 to 64. Result, dead, 200; alive 70. (b) 1 to 256. Result, dead, 30; alive, 45.

No. 16. Common Salt ($NaCl$).—1 to 6. Result, dead, 129; alive, 14.

No. 16. Potassium nitrate (KNO^3).—1 to 8. Result, dead, 178; alive, 68.

In addition to these, tobacco smoke and sulphur fumes were tried in the field. Both were applied with a Crane bee smoker, to badly infested bean plants. The tobacco smoke quickly stupified the insects, but in most cases they eventually recovered.

Sulphur fumes did not seem to have much effect on them.

THE BEST TREATMENT.

Reviewing the experiments thus far made in the field, it will be observed that the Rose Leaf Insecticide gave much the best results. The insects died in most cases when fairly struck by the spray. In the laboratory experiments in 1898, it will be noticed that several insecticides were very efficient when the thrips were bottled up. By the use of the following insecticides, all of the insects treated were killed:

Rose Leaf Insecticide, 1 to 64; Whale Oil Soap (Anchor Brand), 1 to 200; Kerosene Emulsion, 1 to 16; Pyrethrum Powder, undiluted; Hammond's Thrip Juice, 1 to 40.

But it does not necessarily follow that these insecticides would be as efficient in the field. Thus, the Whale Oil Soap used in the field experiments last year, did not compare favorably with results obtained from the use of Rose Leaf, while in the laboratory the results were identical. It should be noted, however, that different brands of soap were used in field and laboratory experiments; in the former, a low grade was used, and in the latter, Leggett's Anchor Brand.

And again, by the use of Pyrethrum in the laboratory, all thrips were killed, while in the field, it had little if any effect. This difference in results is doubtess due to the use of pyrethrum, in the one case in a bottle, where the odor is confined, and in the other, in the open air, where its value would be greatly lessened.

In addition to spraying, particularly in the case of strawberries and roses, it would be of much value to carefully remove all blighted flowers, with their flower stalks and quickly throw them in kerosene or burn them. By doing this, numerous thrips and the eggs in the calyces and flower stalks would be destroyed, which would materially affect the abundance of the insects in the future.

Spraying should be repeated as the abundance of the insects demands. Whenever the thrips become so abundant as to be destructive to any kind of plant, they are usually quite abundant in many other plants also, and a field of strawberries, for instance, that has been quite freed from them by spraying, might, in the course of ten or twelve days, become badly infested again.

Hammond's Thrip Juice, No. 2 in the laboratory, proved very efficient. Field experiments are yet necessary to determine if it will be equally effective there. It is believed that by the use of Rose Leaf Insecticide, Whale Oil Soap (Anchor Brand) or Kerosene Emulsion, thrips can be kept greatly reduced, and their ravages minified to a considerable extent.

The use of Kerosene and Whale Oil Soap, however, can hardly be recommended for the treatment of thrips in strawberry fields from which ripe fruit is being picked, from the fact that the fruit would be more or less tainted by the oils of these insecticides. In other cases where no fruit would be sprayed that is to be immediately used, their use would probably prove quite satisfactory. The Rose Leaf, on the other hand, does not injure fruit for immediate use, as it washes off readily, hence everything considered, cost, ease of preparation, range of application and effectiveness, the Rose Leaf Insecticide is recommended in preference to anything that we have yet tried.

HOW TO USE THE ROSE LEAF.

Simply mix it with water at the rate of one pint to six gallons, and apply it thoroughly to infested plants, with a spray pump that gives a fine and forcible spray.

It may be purchased of the manufacturer for 75 cents per gallon, of stock solution; a gallon diluted with the proper amount of water, would make forty-eight gallons of the spraying mixture, costing 1 and 6-10 cts. per gallon. This is approximately the cost per gallon of Kerosene Emulsion, ready for use, not including the cost of its preparation; and somewhat more than the cost of a gallon of Whale Oil Soap solution. It is hoped that a cheaper insecticide may yet be found.

ECONOMIC BIBLIOGRAPHY OF THRIPS TRITICI.

Ashmead, W. H.:
  Orange Insects, 1880. p. 72;
  Insect Life, VII, 1894. p. 27; (on cotton).
Brunner, L.:
  Insect Enemies of Small Grain, Rept. Neb. St. Bd. Agrl. 1893. p. 457;
  Insect Enemies of the Apple in Neb., Neb. St. Hort. Rept.. 1894. pp. 163., 214.
Fitch, Dr. Asa:
  1st-2nd Repts. Ins. N. Y., pp. 304-308.
  Count. Gent. VI, Dec. 13, 1855. p. 385.
Forbes, S. A.:
  16th Rept. Ins. Ill. 1890. p. IX. pl. V;
  17th Rept. Ins. Ill. 1891, pp. XIII. XV.
  Thrips or Strawberry Midget, (*Thrips tritici*), Centralia, Ill. Sentinel 1887; Reprint, Prairie Farmer, June 4, 1887; Insect Life, V. 1892. pp. 126-127.
Hubbard, H. G.:
  Insects Affecting the Orange 1885. pp. 164-165. (U. S. Dep. Agrl).
Lintner, J. A.:
  Thrips in Strawberry Blossoms, Cultivator and Country Gentleman, V. 52, 1887, June 9, p. 459;
  Some Literature of the Thripidae, 11th Rept. N. Y. State Ent. pp. 247-250.
Osborn [illegible]:
  The Canadian Entomologist, Aug. 1883, pp. 151-156.
  Insect Life, 1, 1888, p. 141;
  Insects of the Orchard, Bull. Iowa Agrl. College, Aug. 1884. No. 2. Trans-Iowa State Hort. Society, 1883-84. V. 18.

Powers, S.:
Strawberries and Pears, (Editorial) Florida Farmer and Fruit Grower, Mch. 27, 1897.
Riley, C. V., Howard, L. O.:
Insect Life, 1, 1889. p. 340.
Rolfs, P. H.:
Florida State Horticultural Society, 1897 p. 97.
Townsend, C. H. Tyler:
Canadian Entomologist, 24, Aug. 1897. p. 197.
Webster, F. M.:
Ohio Exp. Station Bulletin No. 45, 1892., pp. 207-208.
Weed, C. M.:
The Strawberry Midget, Prairie Farmer, 59, 1887, p. 343;
Trans. Ill. State Hort. Society. 1887, pp. 230-233;
Popular Gardening, 3, 1888, p. 176.
Insects and Insecticides, 1895, p. 146.

THRIPS TABACI LIND.*

During the spring seasons of the last two years, this species of thrips also has been quite destructive at Lake City, injuring onions, cauliflower and cabbage. The conditions favorable for *Thrips tritici* seem also to have been favorable for its near relative. It has varied considerably in abundance during the spring, at times becoming much reduced, and again it would be present in great numbers. The insect was first noticed about the middle of April in 1897, when it was observed to be infesting onions on the Station gardens. The insects were destructive until about July 1, when they gradually disappeared.

In 1898, the insect was observed, April 28th, to be quite abundant on onions in the Horticultural department, and some days later, Prof. Rolfs called my attention to its occurence on cabbage and cauliflower. To these plants it proved quite

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*I am under obligations to Dr. L. O. Howard for the determination of *Thrips tabaci.*

destructive during May, and the first two weeks of June. By the last of June, the insects were becoming very scarce, and at this date (July 15th) none are to be found. Beginning with July, considerable rain has fallen, which may have hastened their disappearance.

NATURE OF THEIR INJURY.

This species is injurious to the foliage of plants. On the onions, it chafes off the epidermis from the green leaves, thereby causing them to dry out, whiten and frequently die. On the cabbage and cauliflower their effects are about the same. They are much more abundant on the lower surface of the leaves. where they chafe off the leaf substance, much as in their attack on onions. The leaves of cabbage and cauliflower, however, particularly on the lower side, become brown, and have a scalded appearance. Such leaves eventually become much dried up, and doubtless are not of much functional value.

ORIGIN AND DISTRIBUTION.

This insect has even a wider range than *Thrips tritici*; according to Mr. Th. Pergande, Assist. Entomologist, U. S. Dep. Agrl., it occurs in the following localities: Russia, Germany, Bermuda, Connecticut, New York, New Jersey, Pennsylvania. Virginia, Ohio, Illinois, Colorado and California. To these should now be added Florida. It is doubtless of European origin, and has been brought over in some shipment of onions or cabbage. The insect was first made known to science, by Dr. Lindeman, of Moscow, who found it very destructive to tobacco, in Southern Russia. At Lake City, although occuring in cabbage fields adjacent to tobacco fields, it has not been observed to attack tobacco.

The extent of its work in other States may be judged from the following quotation from Lintner's 11th Rept. as State Entomologist to N. Y., p. 244: "This species has been commonly recorded as depredating on the tops of onions, and its injuries have been quite serious at times, as in the instance reported by

Dr. Packard, where in 1872, one-tenth of the crops of Essex Co., Mass., was destroyed by it at an estimated loss of $10,000. In some localities, it has proved so destructive that the growing of the crop had been abandoned. Next to onions, its preference seems to be for cabbage. It might be thought that this was a recently acquired taste, for during the space of twenty years no record appears of its being found upon this plant—the first such publication being that made by me in 1892, in the Country Gentleman, as above cited. It seems that, however, Mr. Pergande has found it recorded in his notes, as occurring in the District of Columbia and Virginia, during the years 1882 to 1888, on the leaves of cabbages. In 1894, its operations on cabbage were studied by Messrs. Sirine and Lowe, of the New York Experiment Station on Long Island. It was not very harmful to the cabbage, as it attacked and killed mainly the outer leaves, and deserted them the latter part of September for onion fields."

FOOD PLANTS.

The following list of food plants is also taken from the same source:

Cabbage.
Kale.
Cauliflower.
Turnip.
Candy-tuft (*Iberis*).
Mignonette (*Reseda ordorata*).
Nasturtium (*Tropaeolum*).
Blanket-flower (*Gaillardia*).
Cone-flower (*Rudbeckia*).
Catnip (*Nepeta cataria*).
Heal-all (*Brunella vulgaris*).
Four o'clock (*Mirabilis*).
Sweet Clover (*Melilotus alba*).
Cinquefoil (*Potentilla*).
Stonecrop—? (*Sedum*).
Squash.
Cucumber.
Melons.
Parsley (*Carum sativum*).
Tomato (*Lycopersicum esculentum*).
Tobacco (*Nicotiana tabacum*).
Jamestown weed (*Datura stramonium*).
Garden leek (*Allium porrum*).
Onion.

To this list should be added Crab-grass (*Panicum sanguinale*, L.) on the leaves of which the insects were collected, May 15th, 1897, at Lake City.

LIFE HISTORY AND HABITS.

According to Dr. Lindeman,* who has studied the life history of this insect in Russia, the eggs are elliptical, of a reddish color, measuring not more than .25 mm. in length, and are glued along the smaller veins of the leaf, on the lower surface. This stage was found to last ten days. Larvae hatched July 10th in large numbers feeding on the leaves, until August 10th, when they suddenly disappeared, and were found to have gone to the stalk and upper side of the leaves, where they passed the nymph stage. On indirect evidence the nymph stage is given as seven days. Thus the life cycle requires forty-seven days. Three generations were observed during the year.

My own observation on this insect during the past spring in Florida, do not agree with those of Dr. Lindeman. The insect was studied, on onions, cabbage and cauliflower, their behavior being practically the same on the three plants. As many as ten insects were bred through all stages, and numerous tubes of thrips were studied with respect to various points.

The eggs were deposited singly, just beneath the epidermis of the plant infested.**

In the onion this may be anywhere on the leaf. In the case of cabbage or cauliflower a slight preference is shown for the veinlets.

The process of oviposition was observed but once. In this case the egg was placed in a cauliflower leaf in about the same way as with *Thrips tritici* but with this difference: previous to cutting a slit in the leaf with the ovipostior, a small patch of epidermis was torn off with the mouth parts. The thrips then advanced, and worked the ovipositor down in this exposed place. Further observation of course is necessary to determine if this is a usual habit, or was accidental in the instance observed.

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*Die Schadlichsten Insekten des Tabak in Bessarabien—pp. 56-59. (Moscow, 1888.)

**In bulletin 27, of the Iowa Agricultural College, p. 139. Prof. Osborn states that the eggs of Thrips alii, Gillette (Thrips tabaci, Lind.) are deposited slightly beneath the surface of the leaf, and imbedded in the cell structure. (The observation is credited to Miss Alice M. Beach.)

The egg of this species is almost colorless, elongate, and curved, very similar indeed to those of *Thrips tritici*. The egg state lasts from three and a half to four days. Upon hatching, the larvae are quite agile, running about readily if disturbed. They are almost transparent in color but become gradually of a greenish yellow color, the greenish tint due doubtless to the contained food. These larvae are somewhat gregarious in their habits, and may be seen feeding together in groups. Like *Thrips tritici* they also use the spines on the end of the abdomen to drive away intruders, by striking right and left. In almost all cases it has the desired effect, and the victim seems glad to get away. The larval stage lasts from seven to nine days, during which time the insect goes through two molts. The first occurs from two to three days from birth, the last, being into the nymph stage. The nymph stage lasts for four days, the insect remainng almost in the same tracks throughout the period, if left undisturbed. No food is taken.

The wing-pads for the first few hours are short, hardly reaching the caudal margin of the second abdominal segment. In two days, however, they are full length, reaching to near the eighth segment. Some four to six hours before molting into the nymph, a larva, in tube bred specimens, leaves the food and retires to as protected a place as possible, where it remains quietly, and gradually becomes somewhat lighter in color. During the nymphal stage these insects move with difficulty, and are plainly at considerable disadvantage. Nymphs were found in some abundance in the field. In onion fields they were found almost entirely down on the bulb, in the loose soil. In the case of cabbage and cauliflowers, they were found hid away in the dead leaves, and in the pits in the leaf scars. Nymphs, however, could not be found in anything like proportionate numbers to the adults and larvae, and it seems probable that the usual place for passing this stage was not found.

The third and last molt of the insect is from the nymph to the adult condition. A newly developed adult is quite light in color, and does not acquire the normal color for twelve to fifteen hours. The length of life of an adult was not satisfactorily determined. Specimens were kept however for nearly three days, when they met with an accident.

From the above it will be seen that the total life cycle of the insect in Florida is approximately sixteen days, a difference of about thirty-one days, from that of its life cycle, in Russia, as recorded by Dr. Lindeman. In Russia three distinct broods may occur yearly. In Florida, there are probably no distinct broods, as all stages may be found at the same time. Allowing for the life cycle at sixteen days a large number of broods could occur during the year, but unfavorable conditions keep them reduced, except during the spring and perhaps early summer, so that it will probably not happen that they will develop throughout a year, according to their capabilities.

DESCRIPTION.

Egg.—Length, .26 mm. (.01 in.); width, .12 mm. (.004 in.); in shape the egg is elliptical and curved. Fresh eggs are clear white. In eggs with advanced embryos, the reddish eyes are distinctly visible.

Larva, First Stage.—(About one-half hour after hatching) Length, .38 mm. (.014 in.); width of thorax, .14 mm. (.005 in.), somewhat fusiform in shape, gradually tapering caudad from fourth or fifth abdominal segment; body, legs and antennae, clear white; eyes reddish. Head in dorsal aspect, about as broad as long; the eyes are situated on the cephalic lateral margins; no ocelli. In cephalic aspect the head is seen to be considerably produced ventrad and caudad, sub-oval in outline. The four-jointed antennae are born from the vertex, and are approximate at base. The basal joint is short, cylindrical, of about one-half the length of second; second joint sub-pyriform, slightly longer than wide; third, sub-spherical, about as long as second. The fourth joint is as long as the proximal four together, club shaped, thickest near the basal third, from where it gradually tapers distally to a point. Joints three and four are ringed; in the distal part of joint four, these are much more pronounced, dividing it into what might be taken for short, indistinct segments. The antennae bear setae which are much more numerous on fourth joint. Legs stout; coxae and trochanters short; femur about as long as tibia and tarsus together. The tarsus appears to be composed of but one joint, which terminates distally in two diverging claw-like processes; the bladder-like expansion on tip of tarsus does not seem to be present in this stage. The abdomen is composed of ten segments; on the dorsum of abdomen are four longitudinal rows of acute setae, and a row also on each lateral margin. On the tenth segment these setae are quite large, being from two to four times longer than the others.

Mature Larva (Second stage).—Length, .94 mm. (.036 in.); width of mesothorax .22 mm. (.008 in.). Body elongate, abdomen tapering caudad from about fifth segment. Head slightly longer than wide. Color greenish yellow, varying to greenish white. Legs and antennae lighter; eyes reddish brown; ocelli wanting. Setae practically as in stage I. Antennae four-jointed;* basal joint short, cylindrical; second sub-cylindrical, about twice as long as first. Third joint a fourth longer than second, sub-pyriform, united to second by narrow "neck," rather closely ringed. Fourth, about as long as proximal three together, club-shaped, ringed as in stage 1. Antennae bearing setae, much more numerous on fourth joint. Tarsi without the pronounced claw-like structures of first stage. In other respects essentially as in the preceding stage. (See Fig. 10.)

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*Lindeman regards the antennae as six-jointed, but to me, joint four has not appeared, to allow of being considered as made up of three joints; although there are four more or less well defined parts as determined by the rings, which, if considered as joints, would make seven in all, instead of six.

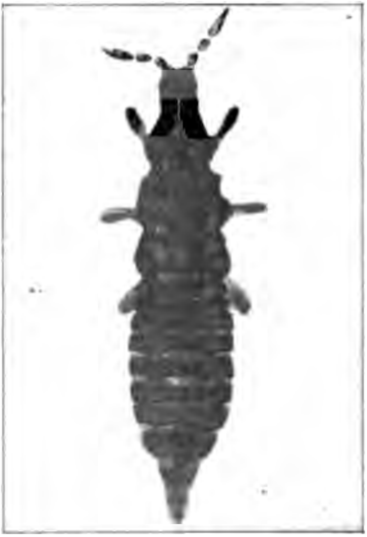

Fig. 10.—Mature larva of *Thrips tabaci*, from a photomicrograph, much enlarged.

NYMPH (about two days old).—Length, about .7 mm. (.027 in.); width of mesthorax, about .15 mm. (.005 in.); color, yellowish, varying to almost colorless, eyes reddish. Pupa-skin somewhat separated from the body proper, being particularly noticeable in the caudal end of the abdomen, wing-pads, legs and antennae. In these two latter, the joints are very obscure, the pupa-skin covering them as a sheath.

The wing-pads reach to about the eighth abdominal segment. There are numerous setae on the body, antennae, legs and wing-pads. On the abdomen they have practically the same position as in the adult larva. The dorsal setae, of the last segment in the nymph, are very stout, almost hook-like, curving cephalad. (See Fig. 11.)

ADULT.—The adult *Thrips tabaci* is 1 mm. long, or somewhat longer, pale yellow, eyes and tip of snout (Russelspitz) black. The caudal margin of the abdominal rings, black in the middle. Body with few short hairs, which on the last two segments appear somewhat longer; upper surface of the body without spines; on the vertex of the head are three small ocelli. Forehead, between the closly placed antennae, with no tooth-like process. Antennae seven-jointed. Joint one, thick, cylindrical; two, barrel shaped, somewhat longer than one, indistinctly ringed; joints three, four, five and six, elongate, elliptical, of almost equal length, except joint six, which is somewhat longer. All are indistinctly ringed. Joint seven, small, cone shaped, a little more than one-half shorter than the preceding joint. Legs simple, thigh not inflated, wings colorless, reaching the caudal margin of the sixth abdominal segment. Their upper surface finely haired. The fore-wing with 2 veins; hind-wing with but one vein. The caudal margin of the wings bear long, dark, wavy hairs, which extend merely as far as he middle of the margin. The cephalic margin bears short, spine-like hairs.

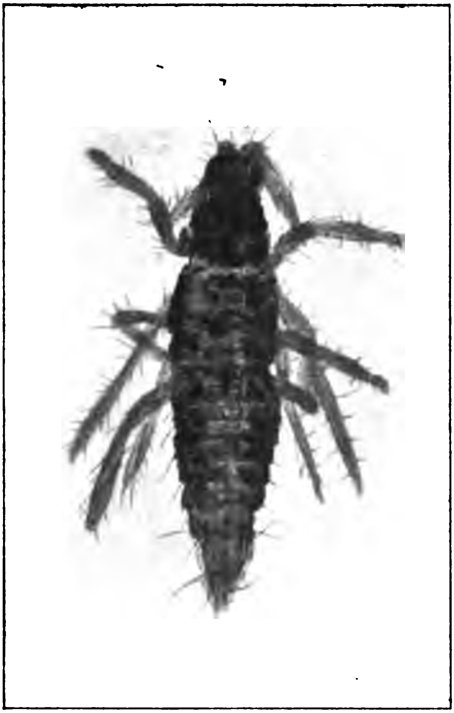

Fig. 11.—Nymph of *Thrips tabaci*, from a photomicrograph, much enlarged. (In figures 11 and 12 the spines and setae are somewhat abnormal, on account of an over zealous retoucher.)

The abdomen of the female consists of ten segments. The two last taper gradually without forming a tube-like ending. The ovipositor, when projecting out, free, is seen to consist of four sword shaped, yellow plates with serrated margins. The receptaculum seminis is situated in the sixth abdominal segment, appearing as a brown pear-shaped vesicle.

The males are smaller than the females. Their abdomen is only nine segmented. In the sixth and seventh abdominal segments lies a pair of brown spoon shaped chitinous plates of unknown function. At the caudal end of the abdomen is the nipple like copulatory organ, whose end bears two colorless hooks, and which is covered from below, by a half-round plate, the ninth segment."—From Lindeman's Die Schadlichsten Insekten des Tabak in Bessarabien, p. 63. (See Fig. 12.)

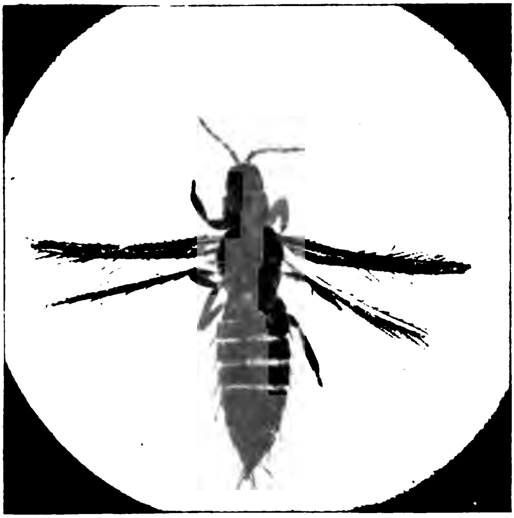

Fig. 12—Adult *Thrip tabaci*, from a photomicrograph, much enlarged.

TREATMENT.

Several insecticides were tried against this insect. They may be successfully controlled by the use of Whale Oil Soap (Anchor Brand), at the rate of one pound of soap to four gallons of water; or by the use of Rose Leaf Insecticide, at the rate of one pint to four gallons of water. The use of Kerosene Emulsion will also be found effective.

In spraying against the insect, it should be done thoroughly; the soil around the plant should also be sprayed as well as the stems of cabbages and cauliflowers, thus destroying the pupae that may be in hiding.

* BIBLIOGRAPHY OF THRIPS TABACI.

Limothrips tritici, Fitch. Packard: 2nd Ann. Rept, Ins. Mass., 1872, pp. 5-8, 3 figs. (Erroneous reference.)

Thrips on Onions Plants, Shipley: In Bull. 10 Miscellaneous Information, Royal Gardens, 1887, p. 18.

Thrips tabaci, Lindemañ: Schadl. Ins. d. Tabak in Bessarabien, 1888, pp. 51-65 (life history, habits, description, remedies).

Thrips sp. Thaxter: in Ann. Rept. Conn. Agr. Expt. Stat., 1889, p. 180 (injuries in Conn.).

Thrips sp. Riley-Howard: Insect Life, 111, 1891, p. 301 (reference); id., VI, 1893, pp. 4-5 (reference).

Thrips sp. Coquillett: in Insect Life, IV, 1891 p. 79, (seriously injuring potatoes and tumble weed).

Thrips tabaci, Lind. Ritzema Bros.: Tierische Schadlinge und Nutzlinge, 1891, pp. 577-578, (description, brief notice).

Thrips sp. Lintner: in Count. Gent., Oct. 27, 1892, lvii, p. 809, (on cabbage); 9th Rept. Ins. N. Y. for 1892, 1893, p. 445, (abstract of notice in Count. Gent.).

Limothrips sp. Baker: in American Florist, 1892, vii, p. 168, fig. (occuring in rose buds).

Thrips striata, Osborn. Gillette: in Bull. 24 Col. Agrl. Expt. Stat., July, 1893, p. 13, figs. 11, 12, (may be n. sp., and suggests allii.); in 5th Ann. Rept. Col. Agr. Expt. Stat. for 1892, 1894, p. 36; in 6th do. for 1893, 1894, p. 55 (referred with doubt).

Onion Thrips. Smith: in Ann. Rept. N. J. Agr. Coll. Expt. Stat. for 1893, 1894, p. 441; in id. for 1894, 1895, p. 447 (abundant); Econom. Entomol., 1896, p. 102 (mention).

Thrips allii, Gillette. Sirrine: in Bull. 83, New Ser., N. Y., Agr. Expt. Stat., 1894, pp. 680-683, plate 11; the same in 13th Ann. Rept. N. Y. Agr. Expt. Stat., for 1894, 1895, pp. 758-760, plate.

---

*The Bibliography is taken from Lintner's 11th Report, as State Ento. to N. Y., pp. 241-242.

Thrips allii, Gillette. Osborn-Malley: Bull. 27, Ia. Agr. Coll. Expt. Stat., 1895, pp. 139-142.

Thrips tabaci, Lind., Pergande: in Insect Life, 1895 vii, pp. 392-395 (general account).

Limothrips tritici, Pack. Webster: in Bull. 58 Ohio Agr. Expt. Stat., 1895, pp. xxxiii-xxxiv (on onions in Ohio).

Thrips tabaci, Slingerland: in Rural New Yorker, lv, 1896, p. 561 (at Peace Dale, R. I.; brief notice with remedies).

To this bibliography should be added:

Thrips tabaci, Lind. Targ. Tozzetti: Animali ed Insetti del Tobacco in Erbal del Tobacco Secco, 1891, pp. 222-224.

ENEMIES OF THRIPS.

Probably the most serious insect enemy of thrips is the *Triphleps insidiosus,* Say. This insect is very common in flowers infested with thrips and has frequently been observed to thrust its beak into thrips larvae and suck from them their body substance. Both the larvae and adults are predacious on the two species of thrips here considered. The eggs of this Triphleps are placed in the tissues of plants with those of the thrips. In two cases, bean flower stalks were put in tubes to breed out thrips from the contained eggs. In these flower stalks were eggs of the Triphleps also, which hatched, the young feeding on the young thrips; these (about fifteen in number, in one case), were quite destroyed by two Triphleps before the thrips had attained the adult larval condition. The life cycle of the Triphleps is quite short, requiring but about fifteen days.

The larva of a species of Chrysopa was occasionally observed feeding on thrips larvae, which were caught by the long mandibles, and sucked after the usual manner of these insects.

During the spring of 1897, a nematode worm was occasionally pressed from the abdomen of thrips, though it is by no means certain that these were parasitic. Both eggs and adults were to be found at the same time, in one individual.

A. L. QUAINTANCE.

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BULLETIN 47, SEPTEMBER, 1898.

Florida Agricultural Experiment Station.

DISEASES OF THE TOMATO.

By P. H. ROLFS.

The Bulletins of this Station will be sent Free to any Address in Florida upon Application to the Director of the Experiment Station, Lake City, Florida.

VANCE PRINTING CO.,
ART PRINTERS AND PUBLISHERS,
JACKSONVILLE.
1898.

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SUMMARY.

1. The tomato crop in Florida is subject to destructive diseases.

2. These diseases may be controlled more or less completely, depending upon the skill of the grower.

3. Rust, or Black Rot, is the most prevalent disease, but fortunately, it can be easily controlled.

4. The bacterial blight of tomato is the most difficult and destructive disease with which we have to contend.

5. The diseases due to physiological conditions can be controlled only to the extent to which we have control over the physical causes.

INTRODUCTION.

Six years ago the bulletin on the Tomato and Some of its Diseases was published. This edition is exhausted, and so much progress has been made in treating tomato diseases that the present bulletin has become necessary.

No attempt has been made to include all the troubles to which the crop is heir, nor to treat any of them at length. It is hoped, however, that the discussion under each disease is sufficiently clear to enable every tomato-grower to diagnose the diseases treated if they exist in his field.

It has been remarked frequently that we are constantly receiving new diseases; this is an inevitable result of our social condition. Seed and plants are brought from all quarters of the earth, often bringing with them the diseases of the section from which they were brought. This condition cannot be avoided, and we must simply make the best of it. The increase in number of tomato growers increases the liability of contagions spreading from one field to another. But as we come to a more thorough understanding of the needs and diseases of the tomato crop, we come to a correspondingly firmer basis. The increase in number and severity of diseases will force all tomato-growers to adopt the most economical methods of raising the crop, and to follow the best methods for preventing its destruction.

RUST, BLACK ROT, SPOT, BLACK SPOT.

Macrosporium (*Alternaria*) *Solani*, Ell and Mart.

The term "black rot" has been applied to this disease from the fact that it was first studied as occurring on the blossom end of the fruit. At this place the fungus gains an entrance and causes a depression of the fruit, which, at first, looks rather brown and later turns to a dark velvety appearance, due to the fact that numerous spores are formed on the outside of the tomato at this point.

The term "rust" is applied to this same fungus when it inhabits either the stem or the leaf of the plant. The first intimation of its presence is small, brown spots forming on various parts of the leaves. These spots continue to increase in size,latterly becoming large blotches. Finally the whole leaf may be involved and become functionless. The term "rust" is more appropriate for this stage of the disease than any other that is used to designate this disease, but unfortunately this term usually refers to diseases caused by a different class of fungi.

GENERAL APPEARANCE.

See Figure 1, Plate I.

As stated above, the spots usually begin as very minute dots, which gradually enlarge. These occur most frequently on the outermost end of the older leaves. Usually the terminal leaflet is more involved than those near the stem, but finally all of them become diseased. By looking carefully at spots involving a large portion of a leaflet it will be noticed that more or less of concentric lines occur about the central portion. This appearance is not common to any other disease of the tomato that we have to deal with, and occurs so frequently with this particular one that we may consider it a good diagnostic character. Later in the season, as the disease progresses, it attacks the petioles of the leaves and the main stalk

PLATE I.

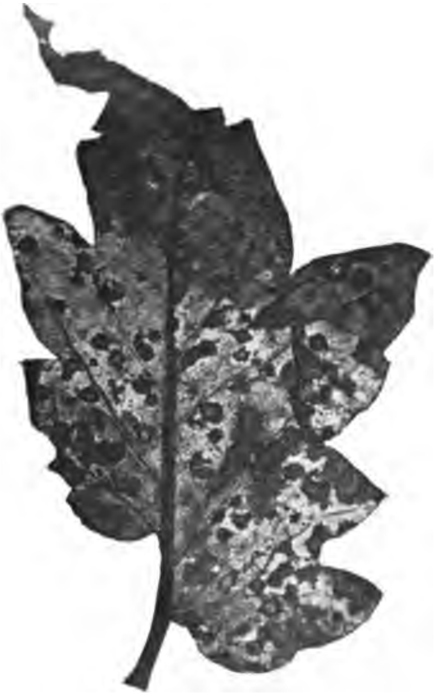
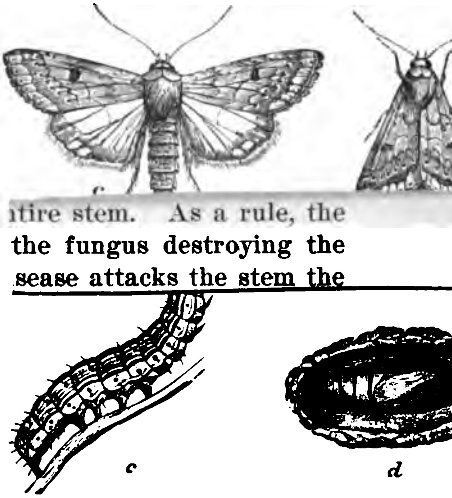


FIGURE 1.



itire stem. As a rule, the
the fungus destroying the
sease attacks the stem the

FIGURE 2.

FIGURE 3.

spores are formed on the
point.

The term “rust” is app

of the plant. Under these conditions the tomato-growers usually speak of it as "spot" or "black spot," so that we have at least four different common names by which this disease is designated. The growth on the stem is so well expressed by the common names used for the disease, that it is not necessary here to describe it further. At the point of attack the epidermis of the plant becomes dry and shrunken, causing the spot to be somewhat depressed; as they become more numerous and increase in size they may encircle the entire stem. As a rule, the greater damage is done by the fungus destroying the leaves and by the time the disease attacks the stem the field has frequently been rendered worthless.

HOW THE DISEASE IS DISSEMINATED.

The disease is the result of the attack of a microscopic plant known by the name given above. This plant develops rapidly within the tissues of its host—the tomato or potato plant. Later it produces spores which, when mature, become detached and may be carried from one plant to another by the wind, or by the laborers working in the field, or a person walking from a diseased field to one that is not affected. Again, the distance to which the wind could disseminate this disease would vary with the conditions.

REMEDY.

All the various kinds of fungicides may be used with more or less benefit in connection with this disease, but the favorite remedy, because of its efficiency and cheapness, is Bordeaux mixture. In every case where this substance has been applied carefully and has been made properly it has given satisfaction. Several tomato-growers have had difficulty, but on inquiring carefully into the trouble it was found to be their own fault. Two cases are distinctly in mind where air-slacked lime had been used in place of the caustic lime. Another case is in mind where the Bordeaux mixture had been properly prepared but it did not seem to give relief. On entering the field it was very evident that the application had been so light that only a very small portion of the foliage had been protected. In this connection, it should be remembered that no fungicide is a REMEDY in the strict sense of the word, it is merely a PREVENTIVE. This form of copper is poisonous to the delicate tissues of the fungus but not poisonous to the more hardy tissues of the tomato plant. As this fungus lives by entering the tissues of the tomato plants it will be at once understood that the copper salts must be present to destroy the fungus or else it will enter the tissues of the tomato plants and cause the disease. In a diseased field there are present millions of spores which are constantly being blown about from one place to another and lighting on almost every inch of space. Now if there be any portion of the tomato plant that contains no trace of Bordeaux mixture and a spore falls upon this place it is just as liable to cause the disease as if the Bordeaux mixture had not been in the field at all. The above brief statement will be sufficient for the thoughtful man to understand that it is absolutely necessary to apply the mixture thoroughly, and since the Bordeaux mixture has no bad effect upon the tomato plants, the grower need not be apprehensive of making the application too heavy.

Bordeaux mixture is used in two different forms in Florida, the wet and the dry. The former has the advantage in covering the plants thoroughly and that it may be applied during the day. The dry Bordeaux mixture must be applied while dew is on the plants and while no wind is blowing. It has, however, the advantage of being much more easily applied. On Terra Ceia Island many tomato-growers have been successful with the dry Bordeaux mixture. From other places we have reports of failures.

Our own tests indicate that the wet Bordeaux mixture is preferable to the dry Bordeaux.

WHEN TO SPRAY. The amount of damage that the disease does varies greatly with the conditions of the weather. During a very moist, warm season the disease spreads with alarming rapidity, while during dry, cool weather it makes little progress. It is better, however, to anticipate the disease by spraying for it before it appears in the field than to wait until it has done a great deal of damage before applying the remedy. Frequently the disease is present in the seed-bed; many tomato-growers, therefore, begin spraying plants in the seed-bed and continue the work after they are set to the field.

The time to spray the seed-bed will vary with the conditions, but it is a highly commendable practice to give the plants one or two thorough sprayings at least before they are set to the field. While this can do no harm, it does a great deal of good other than preventing the black rot.

The number of times to spray the field will vary with the conditions of the weather. If the plants are growing rapidly and we are having a moist season, it may be necessary to spray as often as twice a week. If, on the other hand, the weather be dry with little dew, it will probably not be necessary to spray oftener than every two weeks.

How to Make Bordeaux Mixture—Solution No. 1: Copper Sulphate (Blue Stone) 6 pounds; Water, 50 gallons. Solution No. 2: Caustic Lime (Quick Lime) 4 pounds; Water, 50 gallons.

It is advisable to have three kerosene barrels of about fifty gallons capacity in the field. Dissolve 6 pounds of Copper Sulphate in a barrel of water (50 gallons). The Copper Sulphate will be dissolved slowly in cool water if it be suspended near the top of the barrel in a feed sack or other coarse cloth. If it is desirable to dissolve it quickly, this may be done by placing it in a barrel and pouring on it hot water. After the 6 pounds of Copper Sulphate have been dissolved the barrel may be filled to the 50-gallon mark. Tin or iron vessels should not be used in connection with Bordeaux mixture or the Copper Sulphate solution; always use copper or wooden vessels.

Slack the 4 pounds of lime in just enough water to cover. Be careful to stir it well and see that it does not burn dry. This is best done in a wooden vessel, as there is considerable heat generated by the lime in slacking. If the stone from which the lime is made contains much sand it will be necessary to increase the number of pounds of lime used. If there be a quantity of air-slacked lime present also it will be better to reject this and simply use the part that has not been air-slacked. After the lime has been slacked add water to make 50 gallons.

Stir the Copper Sulphate solution (No. 1) thoroughly and take out about one-half as much as the spraying apparatus will hold. Pour this in third barrel, then stir the lime water thoroughly and take out just as much lime water (No. 2) as copper sulphate solution

BACTERIAL BLIGHT.

Bacillus Solanacearum, Smith.

The disease of the tomato plant caused by bacteria has been known for some time, but it was not until the Fall of 1896 that a complete study of the organism was published. As early as 1892 Dr. Halstead, of the New Jersey Experiment Station, published a bulletin on the work he had done upon the tomato blight in Mississippi. This seems to be the only definite report that we have upon it up to the time that Dr. Smith made the report mentioned before. On page 37 of Bul. No. 21, mention is made of some obscure disease in various sections of the State. It seems quite probable that this disease was the same upon which Dr. Smith reported later, but actual work was not begun upon it, so it is not certain that the two diseases were identical. Up to 1897 this disease had not been reported definitely from Florida, but during that year a number of specimens have been sent to the Experiment Station which seem to be this disease beyond a doubt.

DESCRIPTION.

The symptoms of this disease are very similar to those produced by the fungus blight. This is not surprising after microscopic study of the affected tomato plant has been made. In the case of the fungus blight it cuts off the conductive systems so that the moisture cannot be conveyed from the roots to the leaves. In the case of the bacterial blight these same tissues of the tomato plant are filled with bacteria and a gummy substance produced by them. It is, therefore, not surprising that two diseases which have their origin in two different agents should show symptoms somewhat alike.

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already taken, pour this into the third barrel and stir the two together immediately and briskly for a minute or two. You will then have formed a greenish-colored substance, which is Bordeaux mixture. Put into the spraying pump and apply at once. Bordeaux mixture is not so good after it has settled, and ofter it is twenty-four hours old it had better be poured away and fresh Bordeaux made. The lime water and copper sulphate solution may be kept separately for an indefinite time without deterioration.

The first indications of the disease are the wilting of the leaf, a shoot, or in severe cases the whole plant may wilt. As a rule, this does not attract attention until many plants are attacked and the disease has made considerable progress. When the plant attacked is young, the leaves wilt, the stem shrivels, dries up, standing in its place. Older plants, especially those that are bearing marketable tomatoes, do not die so quickly and show the disease by a yellowing of the affected leaves, or a partial dying of the affected shoot; finally the whole plant is involved and dies. The disease spreads most rapidly in fields where the vines grow luxuriantly and nearly cover the ground. Beside the above symptoms one will find more or less dark matter deposited in the vascular tissues of the petiole or of a stem. This substance may be observed to best advantage in leaves that have yellowed or shown the disease for some time. The petiole or the stem should be cut across with a sharp pocket knife and the dark matter will be seen deposited in more or less of a circle some distance from the centre. (See pg. 11, Bul. No. 12, Div. V. P. & V. P.)

PLANTS AFFECTED.

Beside the tomato, eggplants and Irish potatoes are subject to this disease. Among the wild plants that are affected by it we have the Jamestown weed (Datura stramonium), Black Nightshade (Solanum nigrum), Physalis crassifolia, Physalis philadelphica. Jamestown weed and Black Nightshade are probably the only ones that occur in sufficient abundance in our State to be worthy of note. It may be that after more study has been put upon the disease, a number of those plants will be added to these, but is is not probable that it will affect any other of our cultivated crops.

GEOGRAPHICAL DISTRIBUTION.

The disease was first studied from Charleston, S. C., and is known to exist in Alabama, Washington, and Dr.

Smith thinks it probable that it occurs as far North as New York. That the disease is not indigenous to Florida I think is evident from the fact that it rarely occurs in new portions of the State until after vegetables have been grown for two or three years. The loss from this disease varies from a few plants to, at times, every plant in small areas—ofttimes amounting to as much as 80 per cent. to 90 per cent. of the whole field. There seems to be no special preference for either high or low land and from the nature of the disease we would not look for any difference because of location or difference in condition of soil.

TREATMENT.

Dr. Smith, in his admirable work on this disease, has shown very clearly that this disease is disseminated by insects. The following quotation is taken from his bulletin in full, a copy of which may be secured by any one who will send a money order for ten cents to G. H. Hill, Superintendent of Public Documents, Washington, D. C., with the request that Bul. No. 12, by Dr. E. F. Smith, of the Division of Vegetable Physiology and Pathology, be sent.

NATURAL METHODS OF INFECTION.

In the green house, under strict control of conditions, the writer has been very successful in transmitting the disease by means of the Colorado potato beetle (Doryphora decemlineata.) The first experiment was begun July 23rd, 1896. A handful of beetles was placed under a bell jar on potato tops taken from plants inoculated July 16th. These tops had wilted and were becoming brown. The beetles fed upon them as readily to all appearances as upon healthy shoots. They were then placed for some hours under a large bell jar on a well-grown healthy plant. This plant was eaten in many places, but was not seriously injured. The beetles were then removed and the plant was placed under normal conditions to await developments. On the eighth day there were slight indications of wilt on a dozen different leaves scattered over the plant, indicating as many separate infections. The weather was warm and after a day or two these symptoms progressed rapidly. The wilting leaves shriveled and in a few days long brown streaks appeared inside of the stems, beginning usually at the base of the shriveled leaves. In ten days from the appearance of the first symptoms the whole vine was involved, all the leaves wilted and shriveled, and the stems became muddy green, blackened in stripes internally, and finally shriveled. Cross sections of the stem showed the vessels to be gorged with bacillus. On August 24th the earth was knocked out of the pot and the pot and tubers examined. These were found in all stages of rot.

Three other large, well-grown potato plants were subsequently inoculated in the same way and with the same result. In each case the disease began simultaneously in many different parts of the vine, seven to nine days after the beetles were removed, and the tubers were rotted in whole or part three weeks after the appearance of the first symptoms on the foliage. The check plants remained healthy.

These experiments with the Colorado potato beetle seem to fully warrant the conclusion that insect enemies are largely responsible for the spread of this disease. The direct injury resulting from their bites and punctures is not the only injury nor the worst one. Given one diseased vine in a field and plenty of insects to feed upon it, and the transmission of this disease to all parts of the field, and thence to the whole neighborhood, is only a question of a few weeks.

Just what insects are most instrumental in disseminating this parasite in any particular locality can be determined only after a prolonged and careful study of the disease in the field. No experiments have been made with other insects, but it is likely that flea-beetles, blister beetles, chrysomelids, and many other leaf-eating insects may act as carriers of the disease.

No experiments have been made to determine whether this bacillus can gain entrance to the plant through an uninjured epidermis. Most of the infections probably occur above ground and as the result of insect injuries. Very likely there are some underground infections.

PREVENTIVE MEASURES.

The prompt destruction of all leaf-eating insects and leaf-puncturing insects is one of the first things to be considered. How this shall be accomplished with the least outlay of time and money is a matter for the economic entomologist to determine.

Of course the more diseased plants in a field at any given time, the more possible sources of infection. For this reason diseased plants should be removed and burned with great promptness. This is impracticable after a whole field has become infected, but then the mischief for the season has been accomplished. The time for such precautions is early in the season, when a frequent and thorough search should be made for diseased plants. This can be carried on along with the war of extermination against the insect depredators.

When the disease has become widespread in the fields of tomato or eggplants there is no help for it, but in case of potatoes a considerable part of the tubers may be saved if they are dug immediately and stored in a cold, dry place. Delay in harvesting of the tubers for any length of time after the vines have shriveled means simply the infection of all the tubers and the loss of the whole crop, either in the ground or afterwards in the cellar.

This disease sometimes appears on new ground—i. e., ground recently cleared, and occasionally to such an extent as to lead growers to suspect the seed. The seed, however, is not necessarily the carrier of the disease, since beetles with the germs on their jaws can readily fly from one field to another. Such an explanation of the disease does not, however, preclude the possibility of the germ being permanently at home in certain soils, or of its being spread by seeds or infected seed potatoes. However this may be, the organism probablv lives over winter in the earth of the potato and tomato fields, and therefore such infected soils should be planted to other crops for a series of years before again venturing these two crops or any other solanaceous plants known to be subject to the disease.

To recapitulate, prevention of this disease lies in the direction of the prompt carrying out of the following measures:

(1) Early and complete destruction of insect pests;

(2) Early and complete removal of diseased vines;

(3) In case of the potato, the prompt digging of the tubers and their immediate use or storage in a cold, dry place;

(4) Selection of land for subsequent planting which has not been planted in tomatoes, eggplants, or potatoes for several years;

(5) Selection of tomato and eggplant seeds and potato tubers from plants grown in localities where this disease does not prevail.

RESULTS OF EXPERIMENTS TO PREVENT THIS BLIGHT.

RELATION OF FERTILIZER TO BLIGHT.

The work on this subject was begun last year by putting a block of plants on highly fertilized land and another block adjoining this on land that had not been fertilized for the tomatoes. The two blocks stood out in striking contrast in regard to the growth of tomato plants, but so far as the blight was concerned no appreciable difference could be noted. On healthy, vigorous growing plants the blight seemed to work a little more vigorously than on small, stunted ones, but as all plants on both lots succumbed to the blight, we could not say that either the fertilized or the unfertilized plots had any advantage. The unfertilized plot matured no fruit, while the fertilized plot did mature a few tomatoes. This, of course, is an important difference when it comes to raising tomatoes for market, but the point to be settled here was simply to find out whether there was any advantage in fertilizing or not fertilizing as regards the blight.

This year fourteen 1-100 acre plots were set aside and treated with various forms of fertilizers. Plots 1, 7, 8 and 14 were left unfertilized as checks. In plots 2, 3, 4, 5, 6, 9, 10, 11, 12 and 13 various formulas of fertilizers were used. Five different kinds of potash-kainit—low grade sulphate, high grade sulphate, muriate and carbonate were used as sources of potash. By July 22nd, three-fourths of the plants in the whole field had blighted. The census of the different plots was then taken and as a result it was found that no one form of potash had any perceptible advantage over any other form. The fertilizer was applied very liberally, at the rate of about four tons to the acre, but as the season was unusually dry, the material was used up somewhat gradually, and doubtless a large proportion of it is still in the soil unused.

As a result of the tests of various fertilizers, it may be affirmed :

(1) That no one form of potash is perceptibly better than another.

(2) That bone phosphate is no better than acid phosphate.

(3) That one source of ammonia is as good as another.

(4) That a fertilizer which tends to produce a strong woody stem should be used; on the contrary one that produces rapid growth and succulent stem should be avoided.

RELATION OF VARIETIES TO BLIGHT.

During last year's experiments with blight on the Experiment Station grounds, Red-field Beauty was used and in only one case a plant was noted that seemed to resist the blight when all others about it had been destroyed. Seed from this plant was carefully saved and further work is in progress in this particular line. This year's seed of over fifty varieties which was generously donated by A. W. Livingston's Sons has been tried. Beside these, as many varieties as could be obtained reasonably from other seedsmen are also being used. Among the quantity of trial seeds that were sent to us by W. A. Burpee there are three varieties that are especially blight resisting. Burbank's Preserving is a small tomato about the size of a large currant or a large cherry. A second variety, Dwarf Golden Champion, is also quite resistant to this disease, but this also is a tomato which cannot be recommended for commercial purposes, since the fruit is yellow; a third variety, Ford Hook Fancy, is one that gives a great deal of promise in securing a blight proof variety. While the blight has swept away all of Beauty, and various other varieties around, only one plant out of five (July 20) of Ford Hook Fancy has been killed.

The disease is present in many of the leaves but the germs seem to be unable to make rapid progress as they do in the case of the other varieties and while the others have died, these have continued to give us crops of tomatoes. Some of these plants have been inoculated by the disease for over four weeks and seem at present to have entirely overcome the difficulty. The leaves that were blighted have dried up and hang useless beside the plant, but new leaves have formed and there seems to be no tendency of the disease to spread to other portions of the plant. While this variety leaves many things to be desired for a commercial crop, it is still an important advance in securing varieties that will be excellent for shipping and, at the same time, be more or less resistant to the blight.

In this connection it may be interesting to note that a hybrid between the tomato plant and eggplant has thus far been resistant to the blight, while both of its parents are very susceptible to the disease. Possibly by the process of hybridizing between the tomato plant and the hybrid mentioned above, plants may be originated that will reproduce edible fruits and at the same time maintain the blight resisting qualities of the hybrid.

SPRAYING.

From the nature of the disease, it is manifestly useless to spray with fungicides with a view to protecting the plants against these germs. In spite of this, thorough work with Bordeaux mixture was carried on last year with the result that there was no appreciable difference in the number of blight plants in the sprayed plots and the unsprayed ones. The insects present were nearly all plant bugs which obtained their food by inserting their beaks into the tissue of the plant, so that Paris green could not be used in combating them, and so few were present that it seemed useless to spray with insecticides that killed by contact.

DISTANCE BETWEEN PLANTS.

A considerable advantage may be obtained by having the plants far apart in the field. Where plants were two feet apart the disease spread more than four times as rapidly as on plots where the plants were placed four feet away. After the blight had destroyed all the plants on the plots planted two by two feet, more than 1-3d of the plants were still alive on the plots where the plants were placed 4x4 feet. This, of course, is easily accounted for when we remember that insects are the main carriers of the disease to plants and also that there seems to be a chance for soil infection, so that the plants in the close fields are much more likely to "take" the disease from one another than they are in fields in which they are planted some distance apart. If, therefore, we have a field which we know is infested with diseased plants and must plant it to one of these crops, the plants should be set as far apart as conditions will permit.

FUNGUS BLIGHT OF THE TOMATO.

This disease of the tomato has been studied for a number of years, and the specific organism was discovered about six years ago, but up to the present the conditions surrounding it have been such as do not permit it to be classified and named scientifically. As this is immaterial, so far as the economic aspect of the disease is concerned, not much time has been lost in discovering this point. It will, however, be remembered that fungi belong to plants of low order, many of them being microscopic in size, though others grow quite large, as in the case of toad stools and mushrooms. The tomato blight fungus may live on decaying vegetable matter and upon certain living plants. There seems to be no special limit to the kind of decaying vegetable matter upon which it can subsist, but there are only certain living plants which are attacked by it. For a list of these and a description of the attacks see pages 38-47 of the Annual Report for 1896.

APPEARANCE OF THE DISEASE.

When a plant is affected by this disease a single leaf may be drooping as for the want of moisture. This may become distended again but will continue to droop from day to day as the disease becomes more severe until finally no amount of watering will cause the plant to take on other than a wilted appearance. In severe cases the whole plant may be affected in this way. In less severe cases only one or two branches may show the symptoms

A plant once affected by this disease rarely recovers. Those varieties that have a hard, woody stem are less susceptible than plants with succulent stems. Vigorous growing plants that shade the ground thoroughly are in more danger of attack than those that permit the sun to shine on the soil about the stem and the air to circulate under the foliage, and consequently plants that are pruned and staked are less liable to the fungus blight than those which are not pruned and staked.

TREATMENT.

As the fungus passes most of its life within the soil the reader will at once understand that the point of attack is just beneath the surface. In the case of eggplants it often appears as though some insect had entirely girdled the plant a little below the ground level. The thoughtful reader will at once see that no amount of fungicide applied to the leaves will be of any service. Consequently the material should be applied to the ground, say for about six inches around the stem. It is also advisable to spray the stem of the plant. Bordeaux, although one of our most efficient remedies, is found decidedly wanting for this specific disease. This is because the fungicidal properties are present in the form of a precipitate, or flocculent masses, which are strained out by the surface stratum of sand, leaving the inefficient material to filter below the surface without hurting the fungus. Consequently we should use potassium sulphide*, Ammoniacal solution of copper carbonate** or Eau Celeste***. The first named fungicide is recommended only for home use, as it may be applied with a watering pot and is too expensive for field application. The other substances should be applied with spraying apparatus.

LEAF BLIGHT.

Cladosporium Fulvum., Cke.

This is a fungus disease of the tomato that rarely attacks the plant during our shipping season, but is rather one that interferes with growing of tomatoes for home use. The leaves turn yellow in spots and will be found to be more or less dark colored on the lower side. It differs decidedly from any other disease with which we have to contend in this State. As the disease progresses the leaves become more and more yellow and finally the whole plant may become involved and die for the want of leaf surface· As a rule, however, the plants do not die, but continue to make new growth and simply leave the lower portions of the stem exposed. When a plant is pretty badly diseased it is not able to produce tomatoes but spends all of its energy in making new foliage, which in turn becomes diseased and drops off.

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* POTASSIUM SULPHIDE—Dissolve two ounces of potassium sulphide or liver of sulphur in a gallon of water and apply from one-half pint to a quart to each plant, depending upon the size of the plant, being careful to moisten all portions of the soil where vines lie upon it. It should be remembered that this is advisable only for home gardens, as it is too expensive for use in the field.

** AMMONIACAL SOLUTION OF COPPER CARBONATE—Carbonate of Copper, 8 ounces; Ammonia Water (strength 26 degrees B), 3 pints. How prepared: Put three gallons of water in a wooden or an earthen vessel, pour the three pints of ammonia in this, and stir it to mix the two evenly. Take eight ounces of copper carbonate and shake it into the ammonia water, stirring the liquid all the while. If a considerable part of the copper carbonate remains undissolved, the liquid may be set aside to settle; if, however, all or nearly all of the copper carbonate is dissolved, more of it should be added, in the way described above, until a considerable part remains undissolved; then it is set aside as stated before. After the solution has settled, pour off the clear blue liquid into another wooden vessel. The undissolved copper corbonate may then be treated with more ammonia and water, fresh copper carbonate being added whenever the remaining portion becomes less than an ounce. If the solution is to be kept for more than a day it must be kept tightly corked.

When the fungicide is to be used, one gallon is diluted to fifteen or twenty of water. (Peach trees and eggplant are very susceptible to scalding by chemicals, hence fungicides need to be more diluted for these.)

The stronger ammonia water is recommended because it is usually more economical to buy this and dilute it than to buy lower per cent. ammonia water and pay the additional expenses of transportation.

*** EAU CELESTE—Copper Sulphate, 2 pounds; Ammonia Water (strength 26 degrees B) 3 pints; Water, 50 gallons.

Put the copper sulphate into solution in a small quantity of water, using the same precautions as in preparing this for Bordeaux mixture. When ready to spray add three pints of ammonia, stir thoroughly, dilute to fifty gallons and apply. This is a very cheap and easily made fungicide, but it is liable to scald the foliage of some plants, especially eggplant.

REMEDY.

Thorough sprayings of Bordeaux mixture (see foot note page 127) will protect the new leaf area and prove an efficient check. The spraying should be repeated every week or so. If the rains are heavy and abundant, the spraying should be more frequent.

DAMPING OFF.

Damping Off is a term used to designate a disorder among seedlings either in the field or in the plant-bed. It is characterized by the falling over of an apparently healthy plant, and at first sight it looks as if the plant had recently been cut off. So striking is this appearance that the gardener in most cases credits flea-beetles or cut worms with the mischief. A little closer observation, however, will reveal the fact that the plant is not cut off but still hangs by the epidermis to its root. By examining it under the microscope or hand lens one may see that the interior of the stem of the seedling has been quite decomposed, just at the ground level, leaving the top too heavy to be supported.

The agents that cause this damping off are several species of fungi which are present in the soil and usually live normally upon decaying vegetable matter, but are able to invade the tissues of seedlings. As the condition which determines the presence of these fungi and the remedy for them are practically the same for all the species we will not concern ourselves with the scientific distinction of them, but will rather proceed to the practical way of preventing the damage done by them.

REMEDY.

Since these fungi are indigenous to our State care should be taken not to include them with the material used for the plant-bed. It is a very common practice to gather up leaf mold and such other material as may occur in hammocks and use this for the soil of plant-beds, but this material is, in many cases, severely infected with one or the other of the damping off fungi, consequently it is advisable to compost this with the proper amount of fertilizer and allow it to remain in a moist condition for six weeks or two months before using in a plant-bed, or make a plant-bed of garden soil and the proper amount of fertilizer.

After damping off has made its appearance in a plant-bed water should be withheld as much as possible and only applied during the mid-portion of the day, say from 10 o'clock in the morning to 2 o'clock in the afternoon, as there is no danger of scalding the tomato plants by watering at this time. Then the surface should be worked to a depth of an inch or two with some small tool, such as a table fork. This breaks the soil up and lets it dry out well at the surface, killing much of the fungus that may be present. Then the plant-bed should be as thoroughly ventilated as possible, all obstructions, such as frames or plant cloths, be removed, that the sun may have a chance to shine upon the ground as much as possible, and the air to circulate and help to dry the surface. If rains occur, the plants should be protected and this run off. If too much water has been applied a part of this may be absorbed by using dry sand, sprinkling it among the seedlings. During the rainy season it will be necessary to get this from under buildings or have it piled for that purpose.

When the beds have been put into the best sanitary condition possible, as a further preventive from having the fungus to spread, it may be necessary to remove many plants from the seed-bed so that the nearest shall be at least an inch apart, and then continue to draw out the plants as they begin to shade the ground. While this transplanting will retard the growth of the seedlings somewhat, they will be found to make a much better root system than those that have not been transplanted, and in the end be really better plants to set out than those that have not been transplanted. Under ordinary circumstances these transplanted plants will produce fruit in the field in less time than those that have not been transplanted in the seed-bed.

Mild fungicides, such as sulphur spray, may also be used to advantage. Eau Celeste or copper sulphate, if used at all, should be applied cautiously, as they seem to be quite caustic to seedlings. Probably one or two sprayings of Bordeaux mixture would not hurt the seedlings much, but a frequent repetition of it has been found to be detrimental. Sulphur spray may be used every other day, however, without any perceptible disadvantage.

TOMATO WORM, BOLL WORM, CORN WORM, BUD WORM, ETC.

Heliothis Armigera. Hubn.

See Figure 2, Plate I.

This exceedingly troublesome insect has been described several times and several practical remedies are offered, but still it continues to destroy large quantities of tomatoes, and other products, yearly. Page 19, Bul. No. 23, gives a somewhat detailed account of this pest, also a brief statement of its natural enemies and remedies. On page 309, Bul. No. 34, there is a full discussion of its life history, with figures of the insect in various stages of its development. The accompanying figures are the same as those used in Bul· 34. This bulletin also contains suggestions as to remedies for this insect.

The numerous inquiries regarding this insect that have been received at the offices during the year convince us that it will not be out of place to give here a brief statement as to what remedies have been found practicable in controlling the pest.

REMEDY.

In Florida this insect is constantly in an active state, there being only a very short time during the winter, at best, when they are not feeding actively upon our crops. Fields that are known to be badly infested with the boll worm will be greatly helped by spraying the tomato plants with Paris green about the time the blossoms begin to appear, and then again in two weeks. The young boll worms that are active at this time of year being unable to find tomatoes to eat into, feed in the buds of the plants. Special care should be taken to get the poison well into the buds of the tomato plants.

As soon as the tomatoes have attained the size of a black walnut the worm eats into them and remains there feeding on the soft tissues. From this on it will be useless to use Paris green or any other poison, and there seems to be but one remedy that has been put into practical application by a number of tomato growers. In cultivating the tomato fields careful observation should be made continually to detect any worm-eaten tomatoes that may occur. As soon as these are found to be present in the fields laborers should be sent through to pick all wormy tomatoes. These tomatoes may then be brought from the field and fed to domestic animals, or they should be buried in a pit and covered with at least 18 inches of soil. If the soil be only five or six inches deep there is some danger of the insect crawling out after it has passed through its life cycle and has become a moth. During the picking season all wormy tomatoes should be gathered up as carefully as though they were worth more than the ripe ones, and these brought to some place where they can be either fed or put into a pit as described above. As the life cycle of one of these insects is about 30 days, and each moth may lay as high as 500 eggs, we will see that to let one single worm escape in the early part of the season means the destruction of from 500 to 600 tomatoes 30 days later. It will not require a mathematician to ascertain that only a few worms in the beginning of the season may cause a wholesale destruction of tomatoes two or three months later. The plan of gathering wormy tomatoes has been carried out repeatedly and in no case has any one spoken of it in any other way than commendably.

If this process of destroying the larvae should be carried out systematically for a number of years it will give great relief to the tomato and other vegetable fields.

PHYTOPTOSIS.

Phytoptus Calcladophora, Nal.

See Figure 3, Plate I.

This disease is very frequently referred to as mold and white mold, but as it is caused by an insect mite, and mold always refers to a vegetable growth, these terms are misnomers and should not be continued, though they may be more or less descriptive of the disorder. This insect mite is closely related to the one that causes rusting of oranges. The growing bud of the plant is usually the first to be attacked; soon the fruit buds are attacked, causing white hairs to grow out from the epidermis (see figure 3, plate I). In severe cases these false hairs become so dense that it appears felty. Since this disturbance is confined to the buds and rapidly growing portions of the plant, the tomato growers will have no difficulty in distinguishing this from any other disease. It is especially noticeable in the early morning and late evening, when the sun is near the horizon, causing a peculiar, ashy-white appearance of the affected plants This is visible at a distance of several rods.

DISTRIBUTION.

In America this mite seems to be confined to Florida. A disease which is doubtless the same has been reported from Spain and Italy, but there is no authoritative statement at hand which says that this particular species of phytops (Phytoptus calcladophora Nal) is the cause of the disease, but since this species of mites occurs in Southern Europe, it may be the author of that disease also.

REMEDIES.

Immediately upon the discovery of the cause (1893) various experiments were put in progress to test the value of different insecticides. Plots in an infested tomato field were treated with a number of insecticides and fungicides. While no decisive results were obtained with it, some information was gained as to the direction in which to experiment. Remembering that sulphur spray was an excellent remedy for rust mite of the orange (Phytoptus citri), experiments in this line were continued, with the result that next year a most satisfactory remedy was found in sulphur spray. Afterwards it was found that flowers of sulphur sprinkled on the plants was also very efficacious. Last year several tomato growers were advised to mix the sulphur spray with Bordeaux mixture. Others were asked to try flowers of sulphur. All of those who have reported upon this experiment believe that these substances are just as good with Bordeaux mixture as when applied separately. Where phytoptus is the only disease to be treated it will be found economical to apply flowers of sulphur with a powder gun. (See page 247, Bul. 34, Fla. Exp. Station.)

ROOT-KNOT.

Hederodera Radicicola.

This disease is so well described by the term root-knot that it is scarcely necessary to go into a lengthy discussion of its general appearance. The disease rarely occurs in new fields and not always in old ones, but as a great many plants are infested by this microscopic worm it has been disseminated to most cultivated fields. The tomato plant is quite severely attacked by it. Nearly every one is familiar with the fact that plants belonging to the bean and pea family are more or less subject to its attack. The cow-pea, velvet bean and beggar weed are our best nitrogen-gathering plants, and these at the same time are often attacked by this microscopic worm. So it is often a puzzling question what one shall do with a field after the tomatoes have been marketed.

REMEDY.

If the field is known to be infested by root-knot all the tomato vines should be gathered immediately after the last shipment has been sent out. These may be piled outside of the field somewhere and either allowed to decompose or may be burned. If they are allowed to decompose the vegetable matter should not be returned to the field, as it contains myriads of root-knot worms which would thereby be returned to the field and produce the very disease which it was sought to be removed. After all the tomato vines have been removed, the field should be allowed tc grow a crop of crab grass or possibly sowed to beggar weed. Velvet bean or cow-pea had better not be used. If, however, the field is free from root-knot the vines need not be gathered, and the field may be sown to any one of these nitrogen-gathering crops. By constantly removing the tomato vines at the close of the shipping season, and before the roots of the tomatoes have begun to decompose, the amount of root-knot in the field may be greatly reduced. Then by following this with crab grass the worm will be still further starved out and finally the field be practically free of the pest. A field on the Experiment Station that was badly infested with root-knot six years ago was practically free from it last year; this result was due to the fact that the plot was kept free from nearly all plants that harbor root-knot.

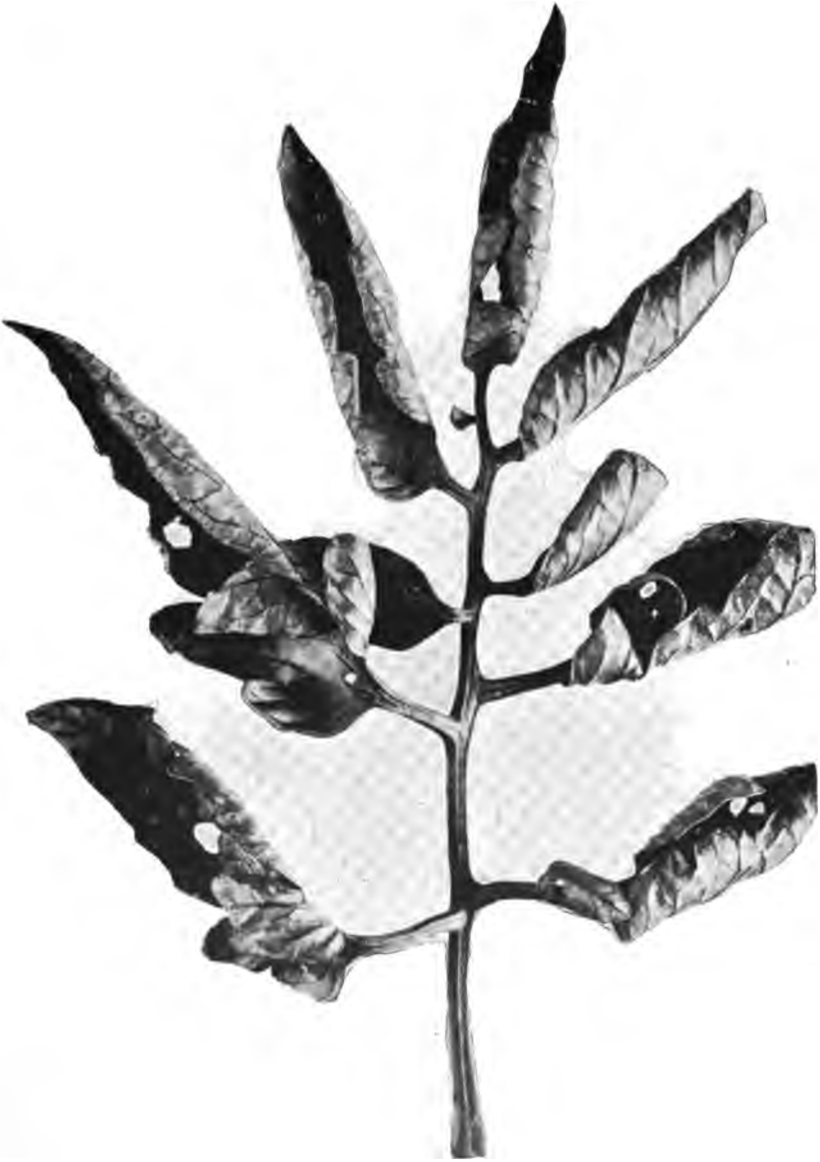
LEAF-CURL, ROLLED LEAF, OEDEMA.

See Plate II.

This disease may also be called dropsy of the tomato, because of the fact that it suffers from an overabundance of water (see plate II). Dr. G. F. Atkinson, Professor of Botany of Cornell University, published a bulletin in 1893 giving a complete discussion of this disease as it occurs in the propagating house of New York. One first notices the disease by seeing the leaves curling up and exposing the under surface to the light. The midribs or veins are always unusually distended and plump. In many cases the leaves will break if bent sharply. In severe cases all the leaves of the plant may be involved, but the older ones suffer first. Sometimes the conditions of cultivation are altered or there is a change to dryer weather so that the disease is discontinued and the lower leaves turn brown. In several localities the term "fired" has been used for this condition.

Where the entire plant may have been involved, the leaves beginning to die from below gradually die to the younger ones. Plants badly affected by this condition fail to bear a reasonable amount of fruit, though the amount produced varies with its severity. When the plants become considerably involved with this disease the buds begin to fall and only a few, or none, set but as the plants look thrifty and vigorous and the fruit-

PLATE II.



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ing buds are usually hidden from sight in such cases, this condition remains unnoticed.

CAUSE.

There are several conditions that lead to this disorder. First, an excessive amount of water in the soil; Second, an abundance of fertilizer or an unbalanced fertilizer, especially such as contains large quantities of ammonia, producing a soft, vigorous growth; Third, the topping or suckering of vigorous growing plants. While none of these conditions acting singly produce much damage, still if two or three of them act in conjunction we are pretty sure to have a field badly affected and very few tomatoes marketed.

REMEDY.

As soon as it is noticed that the tomatoes are suffering from this trouble one should at once cease pruning, if this has been carried on, and let the plants develop as much leaf area as possible. This will give the plants a chance to transpire the water taken in, and assimilate the nutritive material. If the fields are irrigated, withhold the water that is being applied, but this must be done gradually, as sudden stopping of the water supply would be a severe shock to the plants. If the fields are not irrigated and the season happens to be moist, much good can be done by cultivating the fields deeply and thus causing the surface of the soil to dry off more rapidly. If, at the same time, a cultivator be passed along closely to the plants, many of the roots will be mutilated and thus diminish the absorbing surface of the plants, which will give the leaves a chance to assimilate all the material that has been taken up by the roots. In other words, it would be an attempt to increase the proportion of foliage to that of the root system. Experiments conducted for several years in this line show that this plan may be followed safely and with a reasonable hope of remedying the evil. There are other conditions, such as the relative temperature of the soil and atmosphere, over which we have only slight influence, and these will not be considered here.

Some varieties of tomatoes, especially those producing large leaves and large fruit, are somewhat more liable to suffer from this disease than such varieties as Dwarf Champion and others belonging to that class. Beauty Stone, Red-field Beauty, and others that are commonly grown in the State, may be grown with a great deal of confidence if we take the precautions to alter the conditions of soil and plants as above indicated in proper time.

DROPPING OF BUDS.

DESCRIPTION OF THE DISEASE.

The heading of this topic is so expressive of the disease that one scarcely needs to describe it. The plants and condition of the field are quite normal, but one notices that the earlier blossoms begin to drop off, then the later ones, and so on until every blossom on the hand, or even on two or three hands consecutively, have fallen.

In 1893, one of the largest tomato growers in Lake county said that he had lost more fruit by the dropping of buds than other causes combined. Others complained of the same trouble. Beside the fact that attention has been called to this disease while in the field, numerous letters have been received inquiring about the cause of this difficulty. No section in the State seems to be exempt from it.

CAUSES AND REMEDIES.

Immediately upon receiving information as to the nature and destructiveness of this disorder, attention was directed to ascertain the cause. A large field of tomatoes was planted, including some twenty-five different plots. Various operations were performed upon different plots of these tomatoes.

The following brief summary states what has been learned from the work conducted with them. It would hardly be profitable to the tomato grower to publish the details of the experiments. We will, therefore, concern ourselves mainly with the statement of the results.

One of the first points discovered was that during and following cold weather many of the buds dropped. This was doubtless due to the partial arrest of the vegetative functions of the plant, just as during dry weather or in transplanting blossoming plants they are liable to lose their buds. This is not under our control, however. It may also have been due in part to the want of the pollen to take.

Another very general cause for the dropping of the buds has been worked out by a number of the Experiment Stations of the North, especially Ohio and New York. The tomatoes being grown in propagating houses for winter market, it was not difficult to have temperature, moisture and other conditions under complete control. It was found, however, that where the atmosphere was entirely quiet, as would be the case in a propagating house, the flowers would not be pollinated and consequently would be aborted, causing the dropping of the buds. Several measures were introduced to correct this. In one case bees were brought into the propagating house to work upon the flowers, and thus disseminate the pollen. It was found, however, that the more certain and effective way was to take a small paddle and tap each plant during the portion of the day when the atmosphere of the propagating house was dry. This caused the flowers to be pollinated and the fruit to set. While this may be the cause of some unfruitfulness among our tomatoes, we are forced to believe that it is of rare occurrence. There is usually enough wind abroad to shake the plants, while at night the insects are flying if the temperature is high enough to permit the plant to grow.

CAUSE UNDER OUR CONTROL.

The above causes for the dropping of buds are not under our practical control, but there is another cause which is under our control and causes more buds to drop than all others combined. In the early stages of the plant, when the first hand of blossoms is put out, the fertilizer is taking its most active effect and the plant grows vigorously. This diverts the nutriment to the growing point of the plant in place of its being sent to the blossom. The blossoms receiving too small an amount of nourishment, soon drop for the want of nutriment. Happily for the tomato grower, this condition can be changed. Where it is desirable to have tomatoes as early as possible, the plants may be topped as soon as the first blossoms are open. At this time the second hand of blossoms is just well in sight, so that the topping may be done just above the second hand of blossoms. The plant thus being relieved of its growing point, directs its nutriment to the next bud available, which is situated on the blossom hand. As soon as it has been directed to the blossom hand new flower buds are produced, aggregating finally to as many or more flowers as should have been produced on two hands, and not infrequently Beauty will set seven, eight and nine tomatoes on a single hand that would not have set more than five tomatoes if the plant had not been topped. Nor is this the only advantage that is gained by topping. Experiments in 1894 showed that the first Stone tomatoes matured in topped plants averaged ten days earlier than those on plants that were not topped. Golden Queen, a much later tomato, matured its first fruit two weeks earlier on the topped plants than those that were not topped. When tomatoes are trained to a single stem and staked, much good can be done by taking out the suckers, or as it is usually called, suckering.

HOLLOW STEM.

GENERAL DESCRIPTION.

Plants suffer from this disorder immediately after being set out from the seed-bed. They may be only a few inches high or eight or ten when transferred. The central portion of the head of the plants remains green, while the large leaves turn slightly yellow. In the course of a week or ten days after setting out, the most severely affected plants fall over as if cut off by worms; on examining them it is found that the lower portion of the stem is hollow, leaving only the skin to support the plant. Further observations will reveal plants in earlier stages. Plants effected with hollow stem make little or no growth.

CONDITIONS WHICH FAVOR HOLLOW STEM.

Immediately upon having our attention called to this disease microscopic examination was begun on plants in various stages of the malady. During the latter portion of its growth it was not difficult to find fungi and bacteria present, but in the beginning of undoubted cases none of these could be found which led to field work with a view of finding what physiological conditions favored or produced the disease. By making diligent inquiry among the tomato growers whose fields had suffered from the disorder, it was found that they had forced their plants in the seed-bed, making a soft, watery growth. This condition was similated on the Experiment Station by using highly nitrogenous fertilizers in the cold frames. The plants were forced until they were eight or ten inches high, and then planted out on the terrace. The soil was rather dry and little rain occurred. It was necessary to apply water to keep the plants from dying from drought. In a week or ten days we had undoubted cases of hollow stem, and very few of the plants made progress at all. The causes of hollow stem may be briefly stated as follows: First, a highly nitrogenous soil in the plant-bed to force the seedlings; Second, an abundance of water to make the fertilizer quickly available; Third, a quick growing variety of tomatoes; Fourth, transplanting without hardening off; Fifth, planting into a dry soil, necessitating the use of water.

No one or two of these conditions will be sufficient to produce hollow stem, but if several of these are acting in conjunction, we will be pretty sure to have the disease as a result.

HOW TO PREVENT HOLLOW STEM.

Some varieties seem to be able to withstand such treatment better than others. Dwarf Champion and its relations gave fewer hollow stems than Ignotum, Mikado, Beauty, Stone and their related varieties.

We wish to continue growing such tomatoes as Beauty and Stone, and consequently some way of avoiding this disorder is desirable. The time to begin is before the seed is sown. When the plant-bed is prepared, use a complete fertilizer. If the soil be brought in from a hammock for the plant-bed, or other soil that contains a considerable amount of ammonia be used, add less than the amount of nitrogen that the formula calls for. If the soil has been prepared properly, care must be taken that the plants do not become leggy in the bed. If they begin to crowd one another, plants should be removed until there is an abundance of room for each individual. This work insures that the stems of the plant develop a great deal of woody tissue and protecting them against hollow stem. The plants that have been removed from the plant-bed and transplanted will be somewhat smaller than those that were not transplanted at the time they were transferred to the field, but in most cases they will be in bloom before the ones that were not transplanted, thus compensating in a large measure for the trouble of first transplanting.

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JAN 18 1909

BULLETIN 48. OCTOBER, 1898.

Florida Agricultural Experiment Station.

A Preliminary Report Upon the

Insect Enemies of Tobacco in Florida.

By A. L. QUAINTANCE.

The Bulletins of this Station will be sent Free to any Address in Florida upon Application to the Director of the Experiment Station, Lake City, Florida.

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GENERAL REMARKS.

The cultivation of tobacco in Florida is an industry that is assuming considerable proportions, and is one that will doubtless allow of much greater development. As usually happens, in the extensive growing of any crop in a new locality, many previously unimportant insects become serious pests; leaving their natural food plants, they attack the cultivated crop, and owing to the great abundance of food, frequently develop in enormous numbers.

To illustrate this condition, as it applies to tobacco in Florida, we have but to mention the "suck-fly" which, previous to the culture of tobacco, was unknown, but which has now become one of the most serious of tobacco pests. Another illustration is to be found in the Tobacco Leaf Miner, which, leaving its natural food plant, the horse nettle, attacks the tobacco plant, causing much damage.

One of the most important factors that enters into the successful cultivation of tobacco, is the reduction of the ravages of these various insect pests, and that growers are quite alive to the importance of this matter, is evident from the interest manifested in the means that may be employed to bring this about.

During the spring of 1896, a study of these tobacco insects was undertaken by the station; although many things have interfered with the extensive study then outlined, yet it has been thought best to present the present preliminary report, in the hope that, by its perusal, tobacco growers may become better acquainted with their most serious insect pests, and in so far as has yet been determined, with the best remedies against them. It is believed that the numerous illustrations will be sufficient, in most cases, to at once call to mind the particular insect under discussion.

THE HORN-WORM—TOBACCO-WORM.

(*Protoparce* spp.)

Florida tobacco growers are doubtless quite familiar with the horn-worm, or tobacco-worm, as it is sometimes called. There are two species of this insect that are included under the common name of horn-worm. These are, the Northern tobacco-worm (*Protoparce celeus*) and the Southern tobacco-worm (*Protoparce Carolina*). The Southern tobacco-worm, however, is much more common. In our insect collection, the Southern tobacco-worm is found to be about six or seven times more abundant than the Northern tobacco-worm. Frequent examinations in the field, indicate that this is approximately the relative abundance of the two insects. So far as the tobacco grower is concerned, however, there is but little occasion to discriminate between these two insects, as their life histories and habits are practically the same. The Southern tobacco-worm is widely distributed over the United States, parts of Canada, the West Indies, and South America. In Cuba, this insect is reported as a very severe pest to the tobacco industry. The Northern tobacco-worm is quite abundant in the Northern states, where in some sections it does much damage. Its Southern limit has not yet been accurately determined, but it is probable, that it does not occur much further south than the United States. These insects pass the winter in the pupa state, down in the soil. In Florida, the adults begin to appear early in May, and soon deposit eggs on the food plants of the larvae. Usually this first brood is not particularly destructive, but it is the next brood, which appears during July, that causes the most damage. There are at least three broods of the horn-worm in Florida, and probably a fourth, although these are sometimes not very well marked, particularly after the July brood. An examination of a tobacco field after this time, usually reveals horn-worms of various sizes, in more or less abundance. The insects occur in varying abundance as late as November, either on neglected tobacco, or other food plants, as tomato. There is much variation in the severity of these insects in different localities of the State, during the same year. Thus, in Gadsden county, the horn-worm has been very abundant during the past season, while at Lake City it has been comparatively scarce. Doubtless the July brood is the one which causes the most serious damage to tobacco plants, and this is particularly liable to be the case, if the May brood has been more or less neglected. During ordinary seasons, however, the bulk of the first crop of tobacco should have been gotten into the barn, before this brood has had time to create much havoc. Late tobacco and the sucker crop, however, need careful attention, to save them from the ravages of this insect. Much damage is also done by the horn-worm in the drying house, by being carried in on the tobacco, where it will feed for some days. They are particularly hard to detect under such circumstances, and care should be taken that they are removed from the plants before they are taken into the barn.

LIFE HISTORY AND HABITS.

Adults, appearing from the pupa condition, soon begin to deposit their eggs. Eggs of this insect are almost invariably deposited singly, and more usually, on the lower surface of the leaves. These hatch in about three days, into very small, green larvae, which resemble the maturer larvae in general shape. Upon hatching, a larva eats a part or all of its egg shell, and soon begins to feed on the tobacco leaves. Five molts are made during the life of the larva, at different intervals. It requires about three weeks for a larva to obtain its growth, and all this time, it feeds voraciously on the foliage of the tobacco plant. A larva confines itself, to some extent, to an entire leaf before attacking another one, (see figure 1) and usually those on the same side of a plant will be eaten first. However, this varies considerably, and a leaf may be only eaten into, and then abandoned for another one. One worm would probably consume the majority of leaves on one tobacco plant during the course of its lifetime. From the green color of these larvae, harmonizing so well with

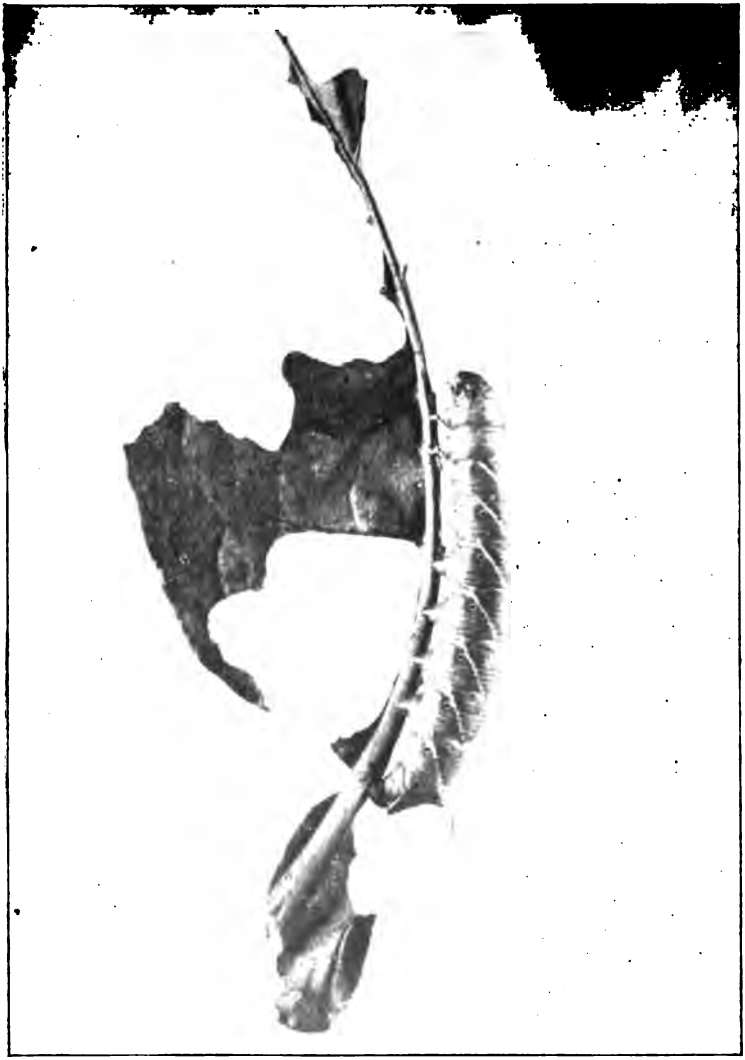

Fig. 1—Illustrating the Southern Tobacco-Worm, on remnant of tobacco leaf. (From a photograph.)

the color of the foliage, they are rather difficult to detect. This is, however, rendered more easy, by the abundant excrement which they void, and which ordinarily will at once attract attention. Upon obtaining its growth, the larva enters the soil to the depth of three or four inches, and enters the pupa state. This condition also lasts for about three weeks, during the summer broods, at the end of which time the adult makes its appearance, and is soon ready to deposit eggs. The life cycle is thus seen to extend over a period of somewhat more than six weeks. Since they make their first appearance early in May, and are to be found as late as November, as many as four broods could readily, and doubtless do, occur in this State.

DESCRIPTION.

The *eggs* of the Southern tobacco-worm are almost spherical in shape, smooth, and are yellowish green in color, and measure about one-twentieth of an inch in diameter. These are quite large enough to be detected with the unaided eye.

The *larva* of this insect, when full grown, measures about three or four inches in length. The head and body are dark green, and the body is marked with lateral, oblique, white bands. On one of the caudal segments of the worm, is a slightly curved, horn-like process, which at one time was erroneously thought to be an organ capable of producing a sting. (See figure 2.)

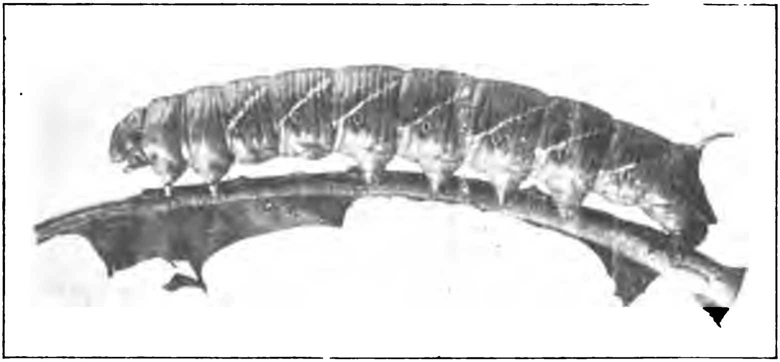

Fig. 2—Larva of Southern Tobacco-Worm. (From a photograph.)

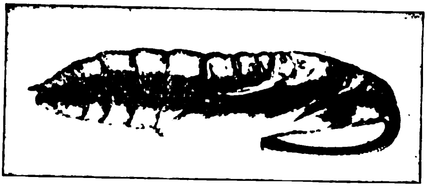

Fig. 3—Pupa of Southern Tobacco Worm. (From a photograph.)

The *pupa* is illustrated in figure 3, as it was taken from the soil of one of our breeding cases. It is a dark reddish-brown in color, about two and one-half inches in length, and is about one-fifth as thick as long. The tongue-case projects somewhat like the handle of a pitcher.

The *adult* of the Southern tobacco-worm is a heavy-bodied insect, with a wing expanse of about five inches. The general color is brownish-gray. The hind-wings are marked with two rather indistinct angulated bands. At the base of each fore-wing is a cluster of white spots, and on each side of the abdomen are five orange colored markings, bordered with black. See figure 4, which illustrates this insect somewhat less than actual size.

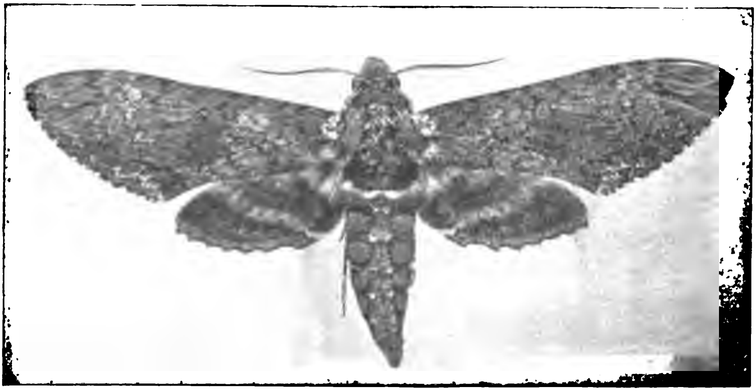

Fig. 4—The adult (moth) of Southern Tobacco-Worm. (From a photograph.)

The *larva* of the Northern tobacco-worm, may be distinguished from that of the Southern worm, by the eight lateral, V-shaped markings, which seems to correspond with the oblique lines of the latter. The pupa of the Northern tobacco-worm is quite similar indeed to that of the Southern tobacco-worm. In figure 5, an *adult* of the Northern tobacco-worm is shown, somewhat less than natural size. It will be seen by comparison of the figures of these different insects, that they may be readily distinguished.

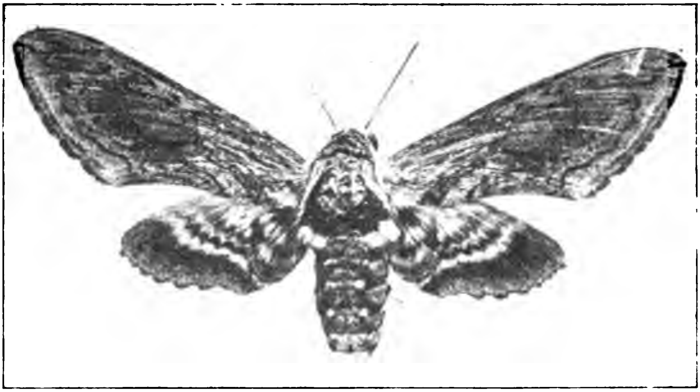

Fig. 5—The adult (moth) of Northern Tobacco-Worm. (From a photograph.)

TREATMENT.

From the solitary habits of this insect, it is more difficult to successfully control than many other species. One method that is much used, in this and other states, is to remove the insects from the plants by hand, and destroy them. This necessitates going carefully over the field at frequent intervals, particularly during the time of the appearance of the broods of adults, and carefully hunting and removing the larvae. This is a tedious and rather expensive process, but is probably one that is mostly depended upon by the tobacco growers in this State. Paris green has come into use to some extent against this insect, particularly in Kentucky, and in certain sections of Florida. Extensive experiments made by Prof. H .Garman of the Kentucky Agricultural Experiment Station, indicate that it is quite practicable to treat this insect with this poison. Prof. Garman, after making a great many tests of Paris green in varying strengths, on both old and young larvae, sums up his conclusions of the experiments as follows:

"1. They confirm the conclusion previously reached that the young worms are more quickly killed than the old ones. Thus the average duration after treatment of lots of small worms was 4.43 days. while the treated lots of large worms persisted on an average of 12.33 days.

2. The length of time required to kill worms increases as the strength of the mixture used diminishes. The average duration of all the lots of worms, of all sizes, treated with a mixture consisting of one pound of Paris green in 40 gallons of water was four days, while the average for the lots which had been treated with the mixture consisting of one pound in 150 gallons is 14.17 days. But it must be added that the increase in the averages is not a regular one, and that some of the lots treated with weaker mixtures lasted longer than others, the worms of which ate more of the poison. In a general way, however, the averages show that worms of all ages fed weak mixtures live longer than those fed strong ones.

3. When worms are young, weak mixtures will serve as well as stronger ones. The average duration of lots of young worms treated with mixtures varying from one pound of Paris green in forty gallons of water to one pound in 100 gallons was 4.11 days. The average of the lots of young worms fed mixtures varying in strength from one pound in 120 gallons to one pound in 150 gallons was 4.67 days, only a trifle greater. The increased time required to kill the worms does not consequently count against the weak mixtures used in these experiments when the young worms are considered alone. That it is of more importance when dealing with large worms, is shown by the fact that the difference in average durations of lots of large worms at the two ends of the series is much greater than in the case of the lots of small worms. Thus large worms fed mixtures varying in strength from one pound in forty gallons to one pound in 100 gallons, persisted, on an average, 8.44 days, while lots fed mixtures varying from one pound in 120 gallons to one pound in 150 gallons averaged 15.25 days."

Some objections have been raised against the use of Paris green on tobacco plants from the fear of injuries that are liable to result to the user. In Bulletin No. 53 of the Kentucky Experiment Station, Prof. Garman reports on the amount of arsenic left on tobacco sprayed with different strengths of Paris green. This report is herewith presented as it represents the most extensive work that has yet been done on this particular question.

THE ARSENIC LEFT ON TOBACCO.

"The important thing to be decided is of course the quantity of arsenic left on the plants at the time of cutting. Without giving details, I will state that if all the fluids used had alighted on the plants and none had dripped from the leaves. there would have been after a single spraying of July 27 on each plant of rows 1 and 2 of plot 1, 2.0659 grains of Paris green, and as about fifty per cent of this was arsenic each plant would have borne 1.0329 grain of this poison. This is a liberal estimate of the quantity of arsenic which these plants received, for probably not more than four-fifths of the fluid used alighted and remained upon the plants.

On rows 1 and 2 of plots 2, 3 and 4, individual plants received 4.0913 grains of Paris green in the two sprayings given these plots, about half being applied July 27 and the remainder August 3. Each plant is estimated to have received 2.0456 grains of arsenic.

The two rows of plot 5 treated with London purple received 4.7395 grains of London purple per plant, or 1.8957 grain of arsenic, considering that the London purple contained 40 per cent. of the poison.

An examination of the report of Dr. A. M. Peter on the chemical examination of sprayed tobacco will show that whatever the original quantity left on the plants, but a small part of it remained there at the time of cutting.

The largest percentage he received by analysis was from plot 4, rows 1 and 2, from which arsenious oxide at the rate of .329 grains per pound of tobacco was obtained. Considering each plant as producing 16 usable leaves and four plants as producing a pound of tobacco the poison obtained by him is the equivalent of .0822 grains of arsenious oxide per plant. Since each plant of these rows received in the spraying 2.0456 grains of arsenic it follows that on the usable part of each plant there remained at cutting time only about 4 per cent. of arsenic originally applied to the plant.

The plants of plot 1, sprayed but once, on July 27, retained on usable leaves only 1.8 per cent. of the arsenic left by spraying.

The arsenic recovered from plants sprayed with London purple amounts to about 3.2 per cent of that applied.

When it is remembered that but little tobacco is swallowed by the user it seems that the small quantities recovered by Dr. Peter show that spraying once or twice, as practiced by us, would not render tobacco in any way injurious,* but I would add that I do not think mixtures much stronger than those we used should be employed, and that not more than three applications should be made during dry seasons.

Suppose we had used three pounds of Paris green in forty gallons of water. With one application each plant would have received 12.3958 grains of arsenic, and if 1.8 per cent. of this quantity remained on the usable leaves at the time of cutting, analysis would have recovered from one plant .2231 grain, which is at the rate of .8924 grain per pound. If two applications of this strength had been made, calculating from the results of our experiments chemical analysis might have recoverèd .9819 grain from the usable part of a plant, which is at the rate of 3.9277 grains per pound of tobacco. This a large quantity, and while these estimates must be considered only as approximations they demonstrate clearly enough the general and essential truth that a quart of Paris green in a barrel of water is more than should be used. If last season had been very wet no doubt less than four per cent. of the poison would have remained at the end of the season, but the part of wisdom is to avoid such strong mixtures, since the weather cannot be safely counted on to remove the excess."

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*Two-thirds grains of arsenic constitute, it is said, a fatal dose for an adult.

From the above it would appear that if properly used, no harm should result from the application of Paris green to tobacco plants, but we have as yet no definite data as to the effect, if any, on the user of tobacco thus treated. There is prejudice, however, among buyers in some cases, against such tobacco. It will be remembered that there has always been more or less of prejudice against the use of fruit and other crops protected from insects by Paris green; in many cases this prejudice has now quite disappeared, from the fact that abundant experience has shown it to be groundless. It was noticeably so in the case of spraying apples against the codling moth. Probably no apple grower now believes that there is the least harm liable to result from the use of fruit properly sprayed with Paris green.

SUMMARY AS TO THE USE OF PARIS GREEN ON TOBACCO.

It will hardly be necessary to make more than three applications of the poison, and these should be at a time when they will do the most good, that is, just as the young worms are beginning to make their appearance on the tobacco. In this State, this will be during the early part, to the middle of May, the early part of July, and the latter part of August. As before noticed, however, these insects do not appear in very closely defined broods, but may be present in more or less abundance in the field, particularly after July. A close watch should be kept, and as the worms begin to appear in considerable numbers, the plants should be sprayed. It will probably be on the side of caution to use weak mixtures of Paris green, as one pound to 160 gallons of water. If this is applied properly, and at the right time, when the worms are young, it will be sufficiently strong to kill them. It would hardly be advisable to use Paris green stronger than one pound to 125 gallons of water and in some cases, this proportion may perhaps be too strong. Probably the best way to apply this would be to use a knap-sack sprayer, the same as recommended for the treatment of the suck-fly (figure 16). A sprayer should be purchased that has an automatic agitator, so that the mixture can be kept thoroughly stirred during its application, thus insuring an even distribution of the poison.

ARSENATE OF LEAD.

The arsenate of lead has also come into use to some extent in Florida against the horn-worm. Its advantages over Paris green are, that it is insoluble in water and hence can be used of any desired strength without burning or spotting the foliage; it is quite adhesive, and will remain on the foliage longer, thus obviating the more frequent sprayings or dustings necessary with Paris green; it is white in color, and is hence visible on the foliage and thus lessens the danger from poisoning.

On the other hand, being insoluble in water, it is slower in poisoning than Paris green and a greater quantity is necessary.

This insecticide can probably be best applied in the form of a powder by the use of a powder gun, such as the Standard Duster, manufactured by Leggett Bros., 301 Pear St., New York. The application of the powdered arsenate of lead will give the most satisfactory results if made in the morning while the dew is still on the leaves. A good application of the powder should be effective for a week or ten days, although its effectiveness will depend much upon the absence of rain, which washes it, to a great extent, from the plants. But since the powder is white, it will be an easy matter to tell when it has become washed off, so that other applications should be made. No poison should be applied to the plants for the week or ten days preceeding harvesting. During very dry weather, it might happen that a considerable amount of the poison would still be on the leaves, when the tobacco was ready for harvesting. Under such conditions, it would be advisable to give the plants a very thorough spraying with water, late in the evening.

It remains to speak of another means that is much used in this State to lessen the number of horn-worms. The fight is waged, however, against the adults, by using flowers of jimson weed, (*Datura stramonium*) and sweetened water poisoned with cobalt. Late in the evening, a quantity of the bloom of the jimson weed is procured, and is placed promiscuously through the patch, in holes in horizontal slats, supported by sticks or otherwise, and into the flower is placed, by means of a quill, a small quantity of this poisoned mixture. This poison should be of about the following proportions: Cobalt, one ounce; molasses, or honey one-fourth of a pint; water, one pint. The adults in their search for nectar frequent these flowers, and are thus poisoned by this mixture, which they feed upon greedily. As each adult deposits something like 200 eggs, it is readily seen the advantage of bringing about their destruction. Many growers cultivate the jimson weed around their tobacco fields, and here and there in the rows. This is advisable, and will save considerable time in placing the flowers here and there in the fields.

ENEMIES OF TOBACCO-WORMS.

Fortunately, there are numerous insect enemies of tobacco-worms that serve greatly to keep them reduced. It is very important that the tobacco grower should recognize these, and foster them. Probably one of the most important enemies of this insect in Florida is a species of Tachina fly (*Sturmia sp.*) This fly lays its eggs on the outside of the larva where they soon hatch, and the maggot works its way to the interior. Here they feed on the tissues of the worm and, have usually about gotten their growth, before the death of the larva occurs, as a result of their parasitism. They enter the pupa state in little brownish puparia within the body of the worm, and eventually develop into flies. Figure 6 shows a larva thus parasitized, and

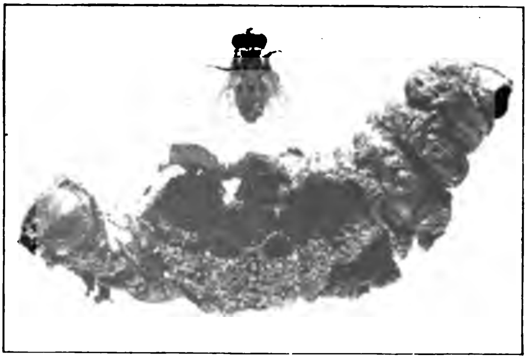

Fig. 6—A Tachnid parasite of Tobacco-Worms, and parasitized larva. (From a photograph.)

from which twenty-two flies were bred, in one of our breeding cases. The fly is shown just above the larva. By careful examination, the cylindrical puparia of the fly may be seen, closely packed together, in the body of the larva.

Another important insect enemy of the tobacco-worm is the *Apanteles congregatus*, a small hymenopterous insect. In figure 7, the larva of a near relative to the tobacco-worm is shown, which has been parasitized by this insect. The small white bodies on the side and back of the larva, are the cocoons of this parasite, the grubs of which developed in the interior of the worm and then made their exit to the outside to pupate. From these cocoons will develop small insects which will deposit their eggs on other larvae.

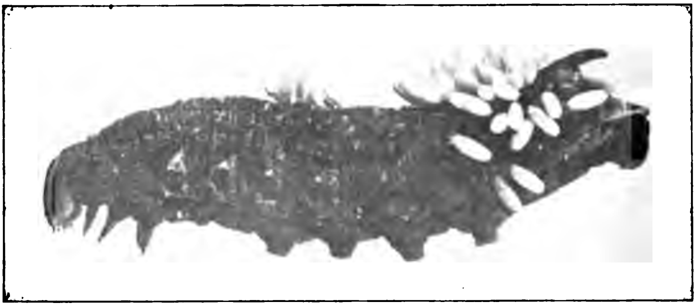

Fig. 7—Sphinx larva, parasitized by Apanteles congregatus, a common parasite of Tobacco-Worms. (From a photograph.)

Probably most tobacco growers are familiar with the large, reddish brown wasps which are very frequently to be seen in tobacco fields. This species is *Polistes bellicosus*, a great friend to the tobacco grower, as it feeds on the young horn-worms and other worms, and does much good in this way. There are also several other species of *Hymenoptera*, as wasps and dirt-dobbers that should be fostered on account of the good they do, in destroying various pests in tobacco fields.

THE SUCK-FLY.

(*Dicyphus minimus*, Uhler MSS.)*

The so-called "suck-fly" of Florida is a very serious tobacco pest. In fact, many tobacco growers affirm that it is the most serious insect with which they have to contend; although it is to be regarded as a new tobacco insect, yet it has been known in Columbia county for the past ten years. Mr. D. L. Geer, a prominent tobacco grower of this section, states that he has been familiar with the insect on tobacco since 1888, at about which time it first made its appearance. Mr. Geer also states that the first few crops of tobacco that were planted in this section, were not infested by the insect. Although this might seem to indicate that it was introduced into this locality from the outside, yet the evidence taken collectively, does not seem to warrant this conclusion and it is probably to be regarded as indigenous, and so far as is known, is confined to Florida.

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*Kindly determined by Dr. L. O. Howard.

The suck-fly enjoys rather a wide distribution over the State, and varies somewhat in abundance in the same locality, during different years. The writer has collected this insect from Quincy, Lake City, Lakeland, Bartow,, Fort Meade and Ybor City; so far as my observations go, however, it seems to be most destructive in Columbia county. In this locality, under usual conditions, the first crop is not damaged to any serious extent, but the sucker crop and late tobacco are frequently quite destroyed. The insects make their appearance in injurious numbers, usually during the first and second weeks of June, although their time of appearance varies somewhat, depending on the nature of the season. The adults are first noticed in some restricted part of the field, as on the plants in one corner, from which they gradually progress, as they multiply, over the field. As their life cycle is quite short, it results that, in the course of a few weeks, they have become quite abundant, and are distributed quite promiscuously over a considerable area. During 1897, the insects were observed in considerable abundance on neglected tobacco as late as Nov. 22nd. This present year (1898) several conditions seem to have contributed to their earlier disappearance. They were quite scarce on the sucker crops in various fields around Lake City by the 1st of September. At this date, Sept. 24th, very few indeed are to be found. According to an observant tobacco grower in this section, "an important factor in bringing about their disappearance has been the absence of rain during the latter part of August, and the early part of September. The sticky exudation from the glandular hairs of the tobacco plant causes many of these insects to become stuck to the leaf, and in this way a great many are killed. The frequent showers keep this sticky exudation washed off to a considerable extent, and thus favors these insects."

The suck-fly injures tobacco by sucking from the leaf the cell-sap, and from the fact that they occur by hundreds on a single leaf, it is readily understood how they are able to so seriously damage tobacco. An infested leaf soon becomes yellowish in color, somewhat wilted, and, in older leaves, eventually splits in various places, along which a browning and drying up occurs, so that the leaf eventually becomes very ragged.

The young of the suck-fly live mostly on the under surface of the leaves. The adults may occur somewhat promiscuously on the younger growth, either on the upper surface or lower surface of the leaves. The adults are very partial to shade, and may be observed feeding close out to the margin of a shadow thrown by a superior leaf. A characteristic of the presence of this insect, when abundant, is the black excrement deposited abundantly, and most noticeable, on the lower surface of the leaves. A leaf may become quite covered with these small blackish spots on the lower surface. Figure 8 illustrates this characteristic, which is from a photograph of a typical leaf, as it appears on the lower surface. Experienced tobacco growers say that leaves that have been badly infested with the suck-fly, are very difficult, if not impossible, to properly cure.

LIFE HISTORY.

The eggs of the suck-fly are deposited singly, in the tissues of the leaf, mainly in the smaller veinlets. They are placed so that the apical end is about level with the epidermis. In our breeding experiments, the egg state was found to last for about four days. In an egg with advanced embryo, the eyes are seen to be distinctly reddish, so much so in fact, that it is usually quite easy to locate an egg in a veinlet, by these reddish spots. In hatching, the young work themselves free, and soon possess

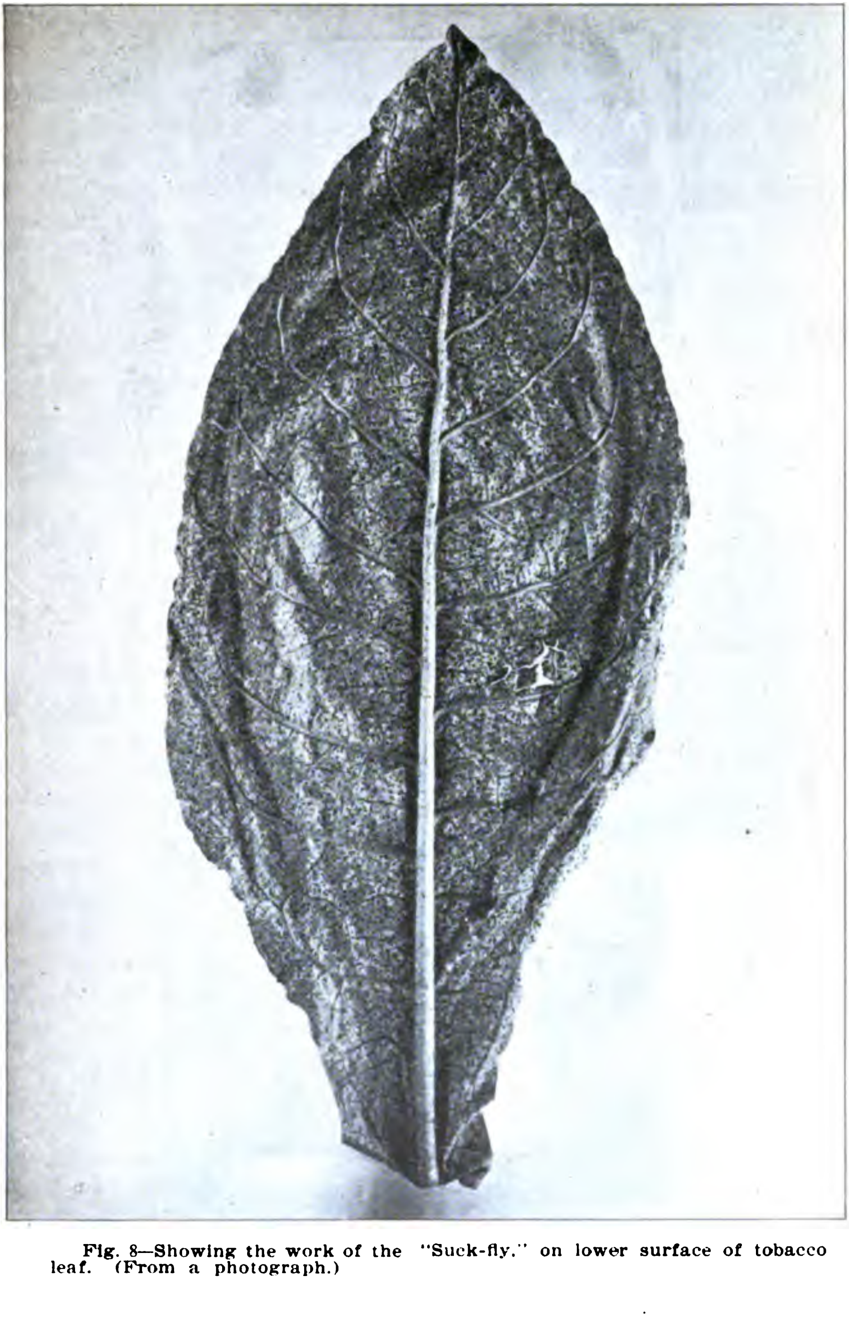

Fig. 8—Showing the work of the "Suck-fly." on lower surface of tobacco leaf. (From a photograph.)

considerable agility. In the course of three or four hours, they have taken sufficient food, that its presence may be detected in the alimentary canal by its greenish color. An insect grows rapidly, and passes through five molts in all, before reaching the adult condition. The first stage lasts about two and one-half days, the second about two days, the third about one and one-half days, the fourth for about two days and the fifth for about three days. The life cycle is thus seen to extend over a period of approximately fifteen days. During all this period, except the egg stage, both young and adults feed voraciously upon the plants which they infest. The number of eggs deposited by adults was not ascertained. However as many as four or five nearly mature eggs were frequently pressed from the abdomen of females. It is probable that they deposit, throughout their life, a considerable number. Adults were kept alive in a breeding cage for six days; it is probable that insects in the field, would live somewhat longer, than under the rather abnormal conditions of a breeding cage.

APPEARANCE OF THE INSECT.

The *adult* is illustrated in Fig. 9, enlarged about fourteen

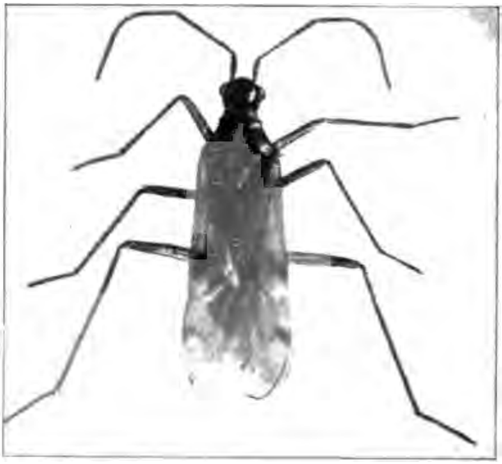

Fig. 9—An adult "Suck-fly," enlarged 14 times. (From a photomicrograph.)

times. It measures about one-eighth of an inch in length, with elongated body, and rather long spindling legs; head about as long as wide, with well developed, rounded eyes. Antennae, five jointed, basal joint very short; third longest. Beak, four jointed, joints sub-equal in length, the basal joint being somewhat fleshy. Tarsi, three jointed. Color of head shining black. Thorax and dorsum of abdomen blackish, the prothorax above with cephalic margin, and a central longitudinal stripe yellowish. Abdomen below, greenish. Legs, yellowish-green, tarsi tipped with dusky. Third joint of antennae, and distal two-thirds of second, blackish.

Nymph.—Fifth stage: Figure 10 illustrates a full grown nymph, enlarged about fourteen times. General color of body greenish, the legs and antennae lighter, eyes reddish. The two pairs of wing-pads are about equal in length and reach to the middle of the second abdominal segment. Antennae five jointed; basal joint short; third and fourth, sub-equal. Tarsi obliquely one segmented.

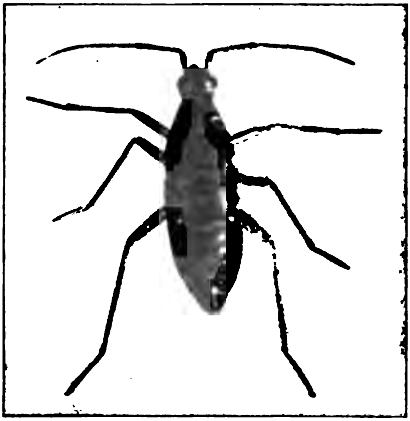

Fig. 10—Nymph of "Suck-fly," enlarged 14 times. (From a photograph.)

TREATMENT.

Various insecticides have been tried against this insect, but it seems unusually difficult to kill. The adults, strangely enough, are killed much more readily than the young. The most satisfactory insecticide against this insect that we have tried, is the "Nikoteen" manufactured by the Skabcura Dip Co., Union Stock Yards, Chicago, Ill. This is a very concentrated solution of nicotine. It is claimed by the manufacturers that the nicotine contained in one hundred and fifty pounds of tobacco has been extracted, and reduced to a solution of about one pint. By numerous tests, both in the field and laboratory, we have found that if this is used at the rate of one part of Nikoteen to sixty parts of water, a large proportion of the adults will be killed, and many of the young. This solution should be applied very thoroughly, both to the upper and lower surfaces of leaves, with a spray pump of some sort that will throw a forcible spray. We have found the Deming Vermorel Nozzle, (figure 17) to be very satisfactory in the use of this insecticide. It should be used with an elbow, so that the under surface of leaves will be more readily sprayed. A Knapsack Sprayer, fitted with a brass elbow and the Deming nozzle, would be a very handy and serviceable combination. This could be manipulated very easily by one man. (See spraying apparatus.)

Finding that this Nikoteen insecticide was so effective, attempts were made to make a decoction of refuse tobacco leaves, so that it would be sufficiently strong to be destructive to the insects. It was found that to meet this requirement, it was necessary to make it at the rate of one gallon of water, to every pound of tobacco. This should be boiled thoroughly for about an hour, and the decoction drained off. This will have evaporated somewhat during the process of boiling, but it will not be unnecessarily strong. After straining to remove all particles of trash that might clog the nozzle of the spraying machine, it is ready to apply to infested plants. Owing to the various organic compounds in this decoction, it cannot be kept more than two or three days, in this climate, before fermentation and decomposition will begin. Hence this decoction should not be made until about the time it is desired to use it. Where there is a considerable quantity of refuse tobacco around, as is frequently the case, it may be more economical to prepare the insecticide in this way, than to purchase the Nikoteen, or extract. Spraying against the suck-fly had best be done early in the morning, as at that time the insects are less agile, and would be more readily covered with the spray. During the heat of the day, the adults fly readily when disturbed, and hence could not be so successfully treated at this time, as when the temperature is somewhat lower. We have not as yet observed that the effect of the tobacco decoction, or of the Nikoteen is injurious to tobacco plants upon which it has been sprayed, and everything considered, it seems to be as nearly harmless as anything we have tried.

In treating the suck-fly, a close lookout should be kept, so that it may be detected upon its first appearance, which will doubtless be during the early part of June, and in some restricted part of the field. As soon as it is observed to have made its appearance, a strong effort should be made to keep it in check as much as possible, by a thorough use of insecticides. If this is done, the subsequent damage of these insects will be greatly lessened. Certain measures are also to be recommended which will serve to keep this insect much reduced in number. As soon as a tobacco field has served its purpose, the plants should be destroyed with the insects on them. This can be accomplished very satisfactorily by pulling up the plants, and laying them in furrows previously plowed, and covering them with the plow as soon as possible. From this procedure it will result, that very many of the insects will be destroyed, and their abundance another year will be materially lessened. The suck-fly has been observed during October, November and early December on tomato vines, and egg-plants. However, they were nothing like so numerous as on tobacco. Diligent search has failed to reveal their natural food plant as yet. It is probably some solanaceous plant of the woods, and its discovery, and destruction would doubtless contribute much to the extermination of the insects.

Among some of the other insecticides tried are the following: Whale-oil soap. This was found to be of little use against the insects although used at the rate of one pound to four gallons of water.

Kerosene emulsion was tried, of various strengths, but to make it effective it should be used at the rate of one part of emulsion to six parts of water. A mechanical mixture of kerosene and water was tried, being applied with the Deming Success Kerosene Sprayer. This mixture was found to be destructive to most adult insects when 10 per cent. of kerosene was used, but this amount of kerosene was very injurious to plants, and further spraying revealed that even 5 per cent. of kerosene would severely scald the plants, even on bright sunny days.

The rose-leaf insecticide was found moderately effective when used at the rate of one part to twenty parts of water.

Carbolic acid emulsion, and a mechanical mixture of carbolic acid in water, were each found to be too severe on the plants to warrant their use against this insect.

Pyrethrum was found very effective when used in closed vessels. When dusted on the plants in the field with a Leggett's powder gun, many of the insects were so affected that they dropped from the plants to the ground, but eventually recovered. Pyrethrum fumes were tried and were not found successful.

Both Sulphur spray and Resin-wash were tried of different strengths, but had little effect on the insects. Neither tobacco nor sulphur fumes proved to be of value.

Rather late in the present season, an attempt was made to introduce among these insects the Muscardine fungus (*Sporotrichum globuliferum*) of the "Chinch-bug." A quantity of fungus was secured through the kindness of Dr. S. A. Forbes, State Entomologist of Illinois. The inoculation experiments were begun in the laboratory. Although it is too early to make any definite statements, yet thus far, our attempts to inoculate the insect with this disease have failed. Insects shut up in boxes, with moistened sand on the bottom to induce growth of fungus, were frequently observed to crawl around over the actively growing fungus, and did not subsequently develop the disease. From the gregarious habits of this insect, it was thought that this fungus might be used with advantage, in its control.

CIGARETTE BEETLE.

(*Lasioderma sericorne*, Fab.)

After tobacco has been successfully grown in the field, and has been cured and packed away in bales or boxes, it is subject to the ravages of a small insect that frequently does much damage. In fact, tobacco if left packed away for two or three years, may become totally ruined by this small beetle. Figure 11 illustrates the way in which the beetle works on stored tobacco. This tobacco was found in a box in the Experiment Station

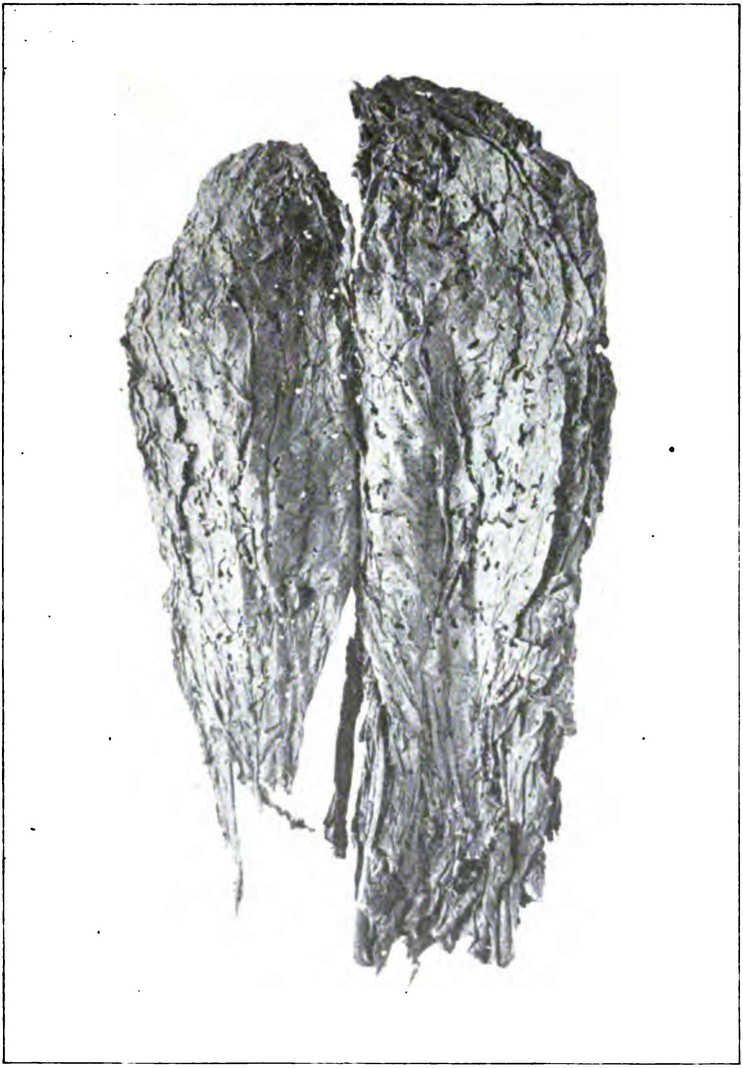

Fig. 11—Illustrating the work of the Cigarette Beetle on stored tobacco. (From a photograph.)

barn, and at the time it was photographed, had probably been infested for about two years.

The insect is very abundant in Florida, infesting many household supplies as pepper, ginger, rhubarb and similar substances. It is also reported as destructive to upholstery. It is one of our worst pests in the Station herbarium and insect collection. Both larvae and adults feed on tobacco, cigarettes and cigars, and as they multiply rapidly during the greater part of the year in this climate, they soon bring about the destruction of the infested material.

The insect is illustrated in figure 12, in its various stages, all enlarged. The hair line at the right of the pupa, b, is intended to represent approximately the actual length. The *beetle* is a little more than one-sixteenth of an inch in length, brownish in color, with the prothorax and head much bent under in front.

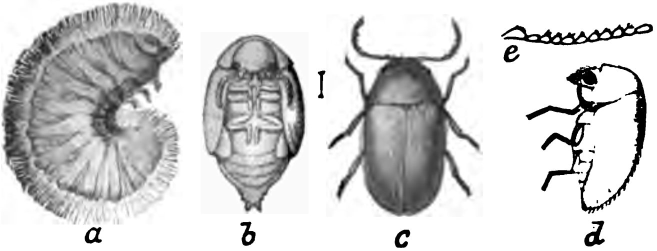

Fig. 12—The Cigarette Beetle; a. larva; b. pupa; c and d. adult. Natural length indicated by hair line. (From F. H. Chittenden in Bulletin No. 4. new series, Div. of Entomology, U. S. Dept. Agri.)

The *larva* is somewhat longer than the beetle, thickly covered with rather long hairs. The *pupa* is white, and is encased in a delicate cocoon.

TREATMENT.

Fortunately this insect, with other insects of similar habits, may be successfully treated. Tobacco that is found to be infested should at once be placed in large, tight boxes, and if tied up should be loosened somewhat, and then subjected to the fumes of carbon bisulphide. The sulphide should be placed in a shallow dish or pan on top of the tobacco. This chemical is highly volatile, and as the gas is heavier than air, it sinks. It is death to all insect life where it becomes thoroughly permeated. Extra care should be taken that the boxes or receptacles of the tobacco are exceedingly tight, and the top should be covered over, after the sulphide is applied, by something that will keep the fumes within, such as a heavy oilcloth or blanket. The quantity of sulphide that should be used will vary somewhat, depending upon tightness of the box. For its use against stored grain insects Prof. H. E. Weed has found that one pound to 100 bushels of corn in a tight granary is sufficient to destroy grain weevils, and other insects. Probably it will be sufficiently strong to destroy this insect in tobacco, to use it at the rate of one ounce to every fifty cubic feet of space in the box. It should be allowed to act for about one day. Carbon bisulphide is harmless to the tobacco, and hence can be used with confidence. In its use, care should be taken that no fire of any kind, as a lighted pipe or cigar, be brought near it, as it is highly inflammable and might cause serious trouble by carelessness in this way.*

THE TOBACCO LEAF-MINER.

(*Gelechia picipelis*, Zett.)

The larva of this small moth is very destructive to tobacco in many parts of Florida. It has been known in this State as a tobacco pest for several years, but no particular effort seems to have been made to reduce its ravages. This has probably been due, to a considerable extent, to the fact that its habits and life history have not been known. The insect is not peculiar to Florida, but occurs in many parts of the United States. So far as present records show, however, it has not been recognized as a tobacco pest except in Florida and in certain parts of North Carolina. In Florida, we have found this insect feeding upon the leaves of tomato, and upon the leaves and fruit of the egg-plant. To the fruit of the egg-plant, it has occasioned considerable damage in certain parts of DeSoto county, by boring into the fruit, thus bringing about their decay. A careful search for the wild food plants of this insect in this locality, has failed to reveal it, but Prof. Gerald McCarthy, formerly of the North Carolina Experiment Station, states that its natural food plant is *Solanum Carolinense*, the common horse, or bull nettle, a very common weed in North Carolina, Florida, and other Southern States. In tobacco fields around Lake City, the larvae make their appearance about the last of May, and may usually be found as late as October.

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*For a more extended discussion of carbon bisulphide, see Bulletin 36, p. 382, of this Station.

These insects injure tobacco leaves, by mining, or eating out patches of *parenchyma*, or leaf tissue, from between the epidermis of the upper and lower surfaces of the leaves. In this respect, they are essentially leaf miners, although the cavity eaten does not resemble the linear or serpentine mines of many species, but is a blotch mine. The result of this work is, that leaves are rendered unfit for wrappers as they split and tear easily on account of these numerous blotches where the tissue has been eaten out. Figure 13 illustrates, from a photograph, a typical example of a leaf infested by these larvae. From this figure it will be seen that the eaten patches are to be found mainly along the midrib and veinlets, for which places the larvae seem to have a partiality. In feeding, a larva does not pass its entire life at one place, but after eating for awhile, it will chew to the outside, and after crawling around over the leaf, will finally enter the tissue again in a new place. From this it will result, that one larva on a leaf during the course of its growth, may render it quite worthless for wrapper purposes, from the numerous blotches eaten. A knowledge of this migrating habit is possibly of value, as it suggests a means for treating this insect, in that it must chew the outside of the leaf to some extent in leaving and entering the leaf, and hence might be poisoned. As a rule, the lower five or six leaves are infested worse than those higher up on the plant.

We have bred these insects frequently in our breeding cages, but despite very careful scrutiny have not, as yet, been able to find the eggs. The life cycle of this insect during the summer is very short, usually not requiring more than twenty days. From this it will be seen that several broods could occur

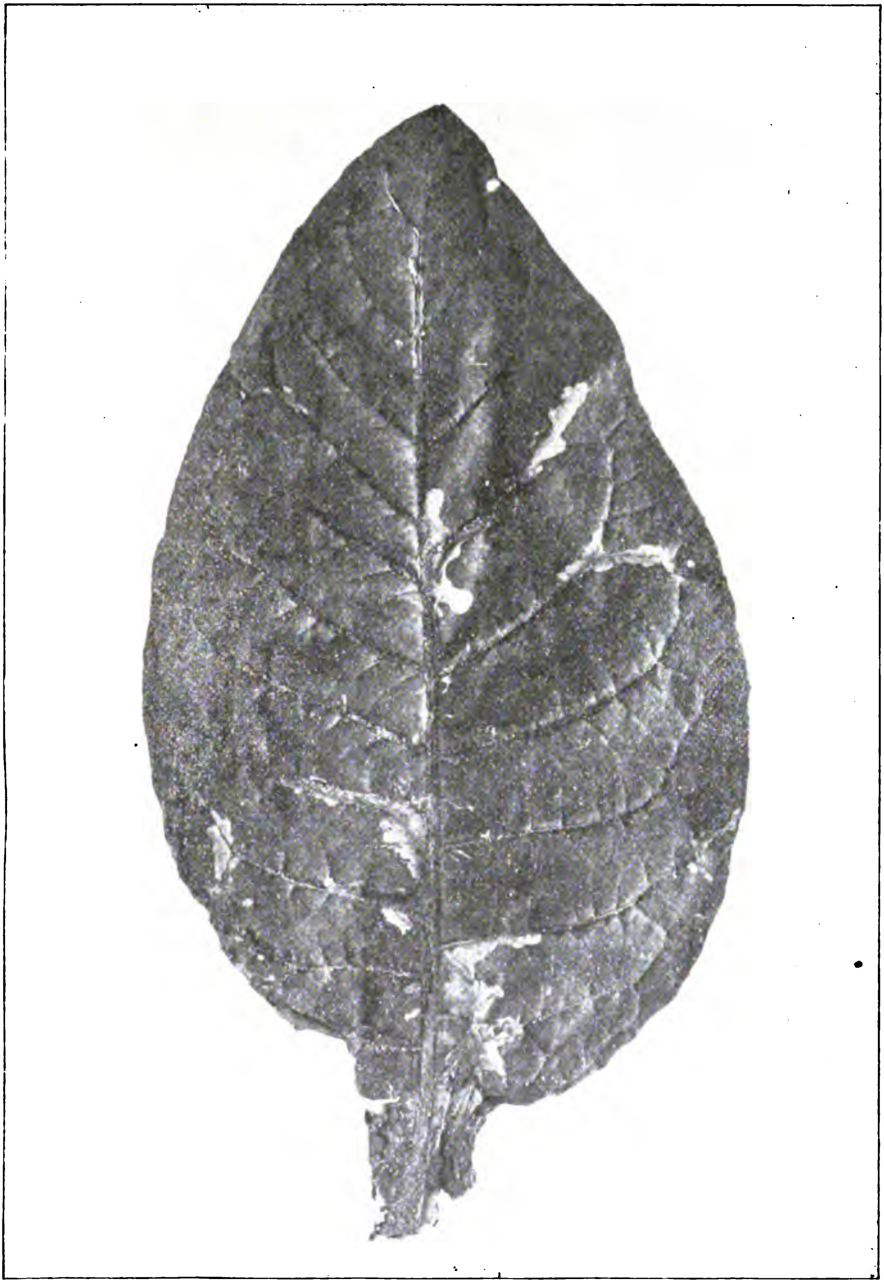

Fig. 13—Illustrating work of Tobacco Leaf-Miner. (From a photograph.)

during the summer. The pupa state is passed on or beneath the soil in the neighborhood of the leaf infested. A slight cylindrical cocoon is made, and in this the caterpillar changes to a pupa, which is first of a greenish color, and later becomes brownish. Doubtless the winter is passed both as larvae and pupae, in the trash around tobacco fields and barns.

TREATMENT.

Doubtless the insect can be controlled to some extent by the use of Paris green, as used against the horn-worm, and where used thoroughly for the horn-worm, the plants should be comparatively free from the ravages of this leaf-miner. Some tobacco growers find it advisable to destroy these larvae by simbly mashing them between the thumb and fingers, as they are detected, by these white transparent patches in the leaf. This can be done with considerable rapidity and will doubtless be found quite profitable. During the winter, care should be taken that all trash from around tobacco barns and in the fields is collected and burned, thus destroying the hibernating larvae and pupae. If this is done carefully, it will doubtless serve to greatly lessen the insects for another year. Where the bull or horse nettle occurs, it would be well to keep a close lookout for these weeds and when found, destroy them, thus removing the natural food plant of the insect.

CUT-WORMS.

Under this caption are to be included the larvae of several different species of moths belonging to the *Noctuidae.* The larvae of these different species of moths, which are injurious to tobacco, are very similar in appearance and as many of them have practically the same habits, we may, for our present purposes consider them as a group. From our breeding experiments, it would seem that *Agrotis ypsilon* is the more common insect destructive to tobacco in this State. However, it does not confine its attention entirely to tobacco, but attacks various plants, as cabbage, strawberries, beans, onions, turnips, corn and other crops. In the strawberry fields, they are frequently found in great abundance. One grower reports that he dug out on an average of 600 daily, for a period of a week, and finally gave up the fight. Another grower reports that he has found as many as 40 near a single plant. These are to be regarded as extreme cases, for there are years when cut-worms, like many other insects, become unusually abundant and destructive. To tobacco, they frequently occasion serious damage, by cutting off, or chewing into the stems of the freshly transplanted plants, so that if they do not die, they are quite liable to be blown over by the wind. The cut-worm is not confined to any particular sort of soil, but occurs in greater or less abundance in almost any locality.

HABITS AND LIFE HISTORY.

The following general statement may be made concerning the habits and life histories of cut-worms. The eggs are deposited by the females soon after their emergence from the pupa state, usually quite low down, on the stems or leaves of various plants. Upon hatching, the young larvae descend to the soil, and feed on the tender portions of herbareous plants. They grow comparatively slow for caterpillars, the larvae hatched in spring, probably becoming full grown by late fall. During the latter part of their life, they are exceedingly voracious feeders, and may occasion considerable damage. During mild winters larvae of *Agrotis ypsilon* are to be found of various sizes, from early fall until late spring, and it seems probable that there is but little regularity as to the time of appearance of the adults. Many cut-worms in this State, pass the winter either as larvae or pupae.

APPEARANCE OF A CUT-WORM.

The greasy cut-worm, the larva of *Agrotis ypsilon*, when fully grown, is about an inch and a half long, with rather stout and plump body. Its general color is brown, or a dull gray, varying to lighter. The head is darker than the body, and is darker above than below. The tips of the mandibles are black. Just behind the head on the first segment, the prothorax, is a shield, dark brown in color, and covering the dorsal surface of this segment. There is much variation in markings, but usually there are two pale lines extending down along the back. Along each side, are eight small black spots, the spiricles, or breathing pores. A few hairs are distributed over the body, arising mainly from small black or brownish colored spots.

APPEARANCE OF THE MOTH.

The body and head are a little less than three-fourths of an inch in length. From the head to the tip of the folded wings, is about seven-eighths of an inch. The wings expand almost two inches. Above, the insect is dark brown in general color, and on the thorax below, whitish. On the abdomen below, it is of a gray color, but darker on the sides. The abdomen terminates in a small bunch of yellowish hairs. The fore-wings have usually quite distinct and constant markings of lighter color. The hind-pair are white, margined with dusky.

TREATMENT.

Probably the most satisfactory treatment for cut-worms in tobacco fields is in the use of bran, poisoned with Paris green. Mr. Neylands, a successful tobacco grower of Tampa, Florida, states that he has been very successful in keeping cut-worms in check by its use. This bait should be prepared by thoroughly mixing Paris green with bran, at the rate of one pound of Paris green to fifty or seventy-five pounds of bran. Just before a quantity is to be used, it should be moistened slightly with water sweetened with molasses. A small ring of the poison should be strewn around each newly set plant, or a teaspoon full placed at two or three places. The cut-worms seem to prefer this even to tobacco, of which they are inordinately fond. Where seed beds are badly infested with cut-worms, this poisoned bran should be drilled along in various parts of the bed where it will be readily accessible to them. This poisoned mixture should be renewed around the plants about every third day, to keep it most appetizing for the larvae. Care must be taken that it is not accessible to fowls or stock.

GRASSHOPPERS, OR LOCUSTS.

Several species of grasshoppers are injurious to tobacco. Probably the most serious offender in this State, is the red-legged grasshopper (*Pezzotettix femur-rubrum*), although another species of grasshopper (*Pezzotettix bivitattus*) is also frequently observed chewing tobacco. During August of '97, a species of *Tettiginae* was observed feeding on seedling tobacco plants at Bartow. These seed beds were on very low soil, and consequently were right in the normal habitat of this insect. The damage by grasshoppers consists in chewing holes in the leaves, thus destroying their value for wrappers. These insects can be controlled to a considerable extent by the use of Paris green, as used against the horn-worm.

BUD-WORMS.

(*Heliothis* spp.)

There are also two species of nearly related insects that are referred to as "bud-worms." The larvae of these two species are not very readily distinguished by a casual observer, nor indeed is it essential that they should be, since the habits of the two are quite similar. The more common bud-worm in Florida is the same insect that infests the cotton boll, the fruit of tomato, and the ears of corn. It is known as the boll-worm of cotton, *Heliothis armigera*. This pest probably needs no other introduction to tobacco growers. The other species is known as *Heliothis rhexia*, and is not nearly so abundant. Figure 14 illustrates the adult moth of this insect which was bred out, in one of

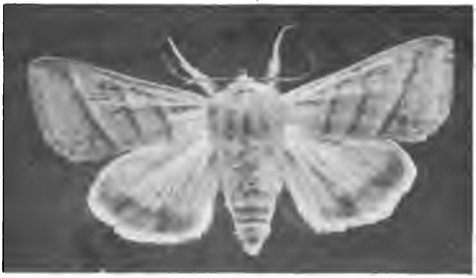

Fig. 14—Adult of one of the Bud-Worms, Heliothis rhexia. (From a photograph.)

our breeding cases, from a larva found feeding on the tender rolled up leaves in the bud of a tobacco plant. The moth is a pretty insect, with a wing expanse of about one and a half inches. The general shape of the body and wings is very similar to that of the adult of the boll-worm. This insect, however, differs considerably in color and markings. The fore-wings are of a beautiful greenish color, obliquely crossed with three lighter lines, which are bordered with dusky on their outer margins. A circular discal spot, may be observed just distad of the basal cross-bar. The hind-wings are whitish, bordered with a brownish fringe. Just within this fringe, on the outer margin, is a broad border of brownish red. The abdomen above, is somewhat rufous in color; below the insect is rather uniformly whitish.

In this State, the true boll-worm is the more serious offender, and hence will receive a greater amount of attention. It seems to prefer corn to most other crops in this and other states, but frequently, owing to lack of this food, it infests various plants, as cotton, tomatoes, okra, tobacco, etc. Feeding on corn, the larvae eat the leaves, quite riddling them with holes, and later, when the ears begin to form, these are attacked. The worms make their entrance, usually from the free end. Later in the summer when the corn is "set," or has become hard, it is not so much relished, and they frequently pass to cotton if it is in close proximity, and attack the bolls. During the early part of the year when these insects do not have corn or cotton to feed upon, they are forced somewhat, to attack tobacco. Eggs are deposited by the moths during the evening and night, on leaves of plants on which the larvae are to feed. On the tobacco plant the moths place their eggs in the bud and the resulting larvae do very serious harm by feeding on the young and yet unrolled leaves, eating holes quite through them. Indeed a large worm may quite devour a bud. As the leaves of the bud grow and develop, these holes become larger, and the leaves are thus ruined, for the best grade of tobacco. Later in the season, when the tobacco plants are fruiting, the larvae seem to prefer the unripened capsules, to these buds. They eat holes in the fruit, quite devouring the immature seed. Figure 15 illustrates one of these larvae as it was found feeding on one of these capsules.

DESCRIPTION.

The *eggs* are whitish, somewhat oval in shape and sculptured with polar ribs and cross furrows.

The *larva* varies much in color, from a pink to quite blackish. The dark colored ones being found more frequently during the latter part of the season. When full grown, a larva measures from one and one-half, to two inches in length. (See figure 15.)

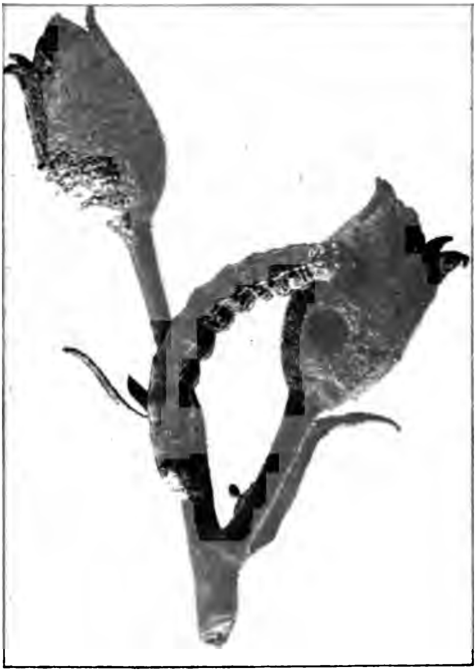

Fig. 15—Larva of Bud-Worm, Heliothis armigera, showing work on seed capsules of tobacco plant. (From a photograph.)

The *pupa* of the boll-worm is about three-fourths of an inch in length, and is of a polished light brown or mahogany color. This is enclosed in a loose silken cocoon, down in the soil.

The *adult* is about as variable in color and markings as the larva. In more typical specimens, the hind-wings are bordered with a broad dark band on the outer margin, on the side of which is usually found a white spot, varying much in size and shape. The fore-wings are frequently bordered somewhat like the hind-wings and marked with a spot at the centre. The wings expand about one and one-half inches.

TREATMENT.

This pest is much more satisfactorily controlled on tobacco than on most other crops. A very usual practice, and one that has proven to be quite satisfactory, is to sprinkle poisoned cornmeal in the bud. This poisoned mixture should be prepared as follows: To a quart of finely ground cornmeal, add a half teaspoonful of Paris green and mix thoroughly by stirring. To apply this, a sprinkler should be made by using a baking powder can, in the lid or bottom of which, numerous holes have been punched so that, when it is shaken, the poisoned cornmeal may be peppered over the bud. The poison should be applied frequently, and after heavy rains. In the case of large plants it may be necessary to open the buds with the hands, and drop in a pinch of the poison.

SPRAYING APPARATUS.

Throughout these pages frequent references have been made to a spraying machine. For the benefit of our readers who are unfamiliar with machinery of this kind, we illustrate in figure 16 the Success Knapsack Sprayer manufactured by the Deming Co., Salem, Ohio. This sprayer is supplied with an

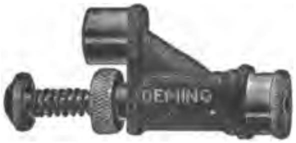

Fig. 17.

automatic agitator, so that in the application of insecticides or fungicides the mixture is kept well stirred, and a more uniform distribution thus secured. At A, in this figure, is shown a brass elbow, which is to be attached to the hose for underspraying, as will be necessary in spraying for the suck-fly. In Fig. 17 is illustrated the Deming-Vermorel nozzle, which we have found to be very satisfactory, as it throws an exceedingly fine spray.

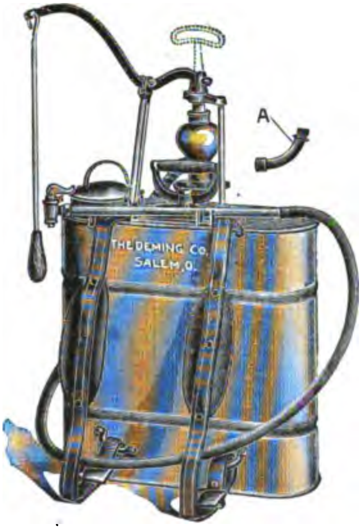
A
THE DEMING Co.
SALEM, O.

Fig. 16.

Among some other manufacturers and dealers in spray pumps should be mentioned: The Field Force Pump Co., Lockport, N. Y., W. B Douglass, Middletown, Conn., and William Stahl, Quincy, Ill. A. L. QUAINTANCE.

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JAN 18

Bulletin 49. March, 1899.

FLORIDA AGRICULTURAL EXPERIMENT STATION.

Cassava as a Money Crop.

By H. E. STOCKBRIDGE, Ph. D.

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The Bulletins of this Station will be sent Free to any Address in Florida upon Application to the Experiment Station, Lake City, Florida.

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INTRODUCTION.

WHAT AND WHY.

This bulletin is not published for the purpose of recording new scientific facts. It will not serve as a burial place for data procured as a result of experiments from which definite conclusions cannot be drawn. Its purpose is to furnish the public with information which it is the endeavor of the writer to make practically useful.

I have now completed two seasons' experiments with this crop, and results, believed to be of value, are here presented with such detail as is necessary for their understanding and interpretation. In my presentation of facts I have not confined myself solely to the results of my own work, but have secured such other data from all available sources as seem to possess public utility. The literature devoted to this crop is, however, extremely meagre, the plant having been but sparingly grown in isolated localities, and there have been but two attempts made by public institutions and scientific men to increase popular knowledge of its adaptations.*

In arranging my experimental work with cassava, as well as in the preparation of this bulletin, I have endeavored to keep constantly in mind its adaptations to the ever increasing demand for a money crop, and it is to its claims for consideration as meeting this demand, and toward solving the problem of its use toward meeting this requirement that I have chiefly directed my efforts.

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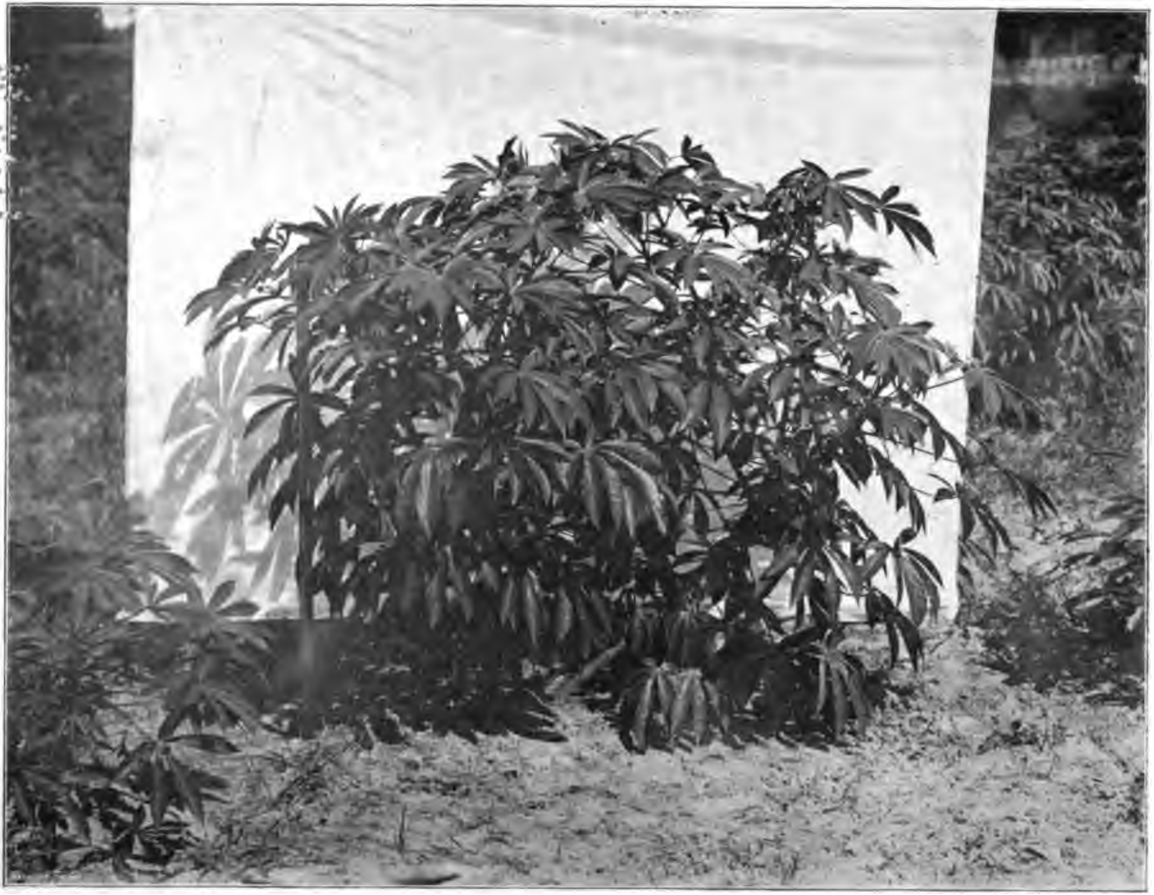
* Bul. 44 U. S. Dept. of Ag., 1894.
Bul. 35 Fla. Exp. Station, 1893.

With the market value of cotton below the actual price of production, with high transportation rates too frequently consuming all the profit of the grower of truck or perishable products, with temporarily unproductive orange groves and the menace of free importation of tropical products hanging over us and demoralizing our markets, the farmer of Florida is today able to sympathize with the widespread claim of unprofitable farming rising from many other states and for sole comfort seek all the satisfaction possible from his advantages of climate which minimize the cost of living and render existence possible even with the proceeds of all farm products at lowest ebb and the returns of farm labor disastrously small.

With an intimate personal knowledge and experience with the present depressed condition of farm business, the writer has not only thoroughly considered all money crop possibilities as sources of relief, but has made very many careful field experiments with all the crops offering any reasonable hope of supplying an additional profitable crop. With all the facts procurable and with the experience of not only myself, but many practical farmers to support the opinion, I have reached the conclusion that, all things considered, cassava comes nearer furnishing the Florida farmer with a universally profitable crop than any other which he can grow on equally large areas. It can be utilized in more ways, can be sold in more different forms, can be more cheaply converted into staple and finished products and can be produced for a smaller part of its selling price than any other crop.

This bulletin is devoted to the presentation of the more important facts upon which these conclusions are based.

UofM



GROWING CASSAVA PLANT.

I

THE CROP.

ORIGIN AND HABITAT.—Cassava is a native of tropical America, and has, ever since the white man first became familiar with American conditions, served as the chief article of diet for the aboriginal peoples of the West Indian islands, Central America and equatorial South America. Botanically it is known as "Manihot utilissima," and Manihot, or Manioc, are the names by which it is commonly designated by the natives of South America, by whom the original word for cassava was applied simply to the manufactured product obtained from the plant. Two varieties of cassava are recognized, one of which is poisonous from the considerable quantity of hydrocyanic acid stored in its roots, and is recognizable by the fact of possessing seven divisions to its leaves, while the non-poisonous variety shows but five, or less, points to its palmately divided leaves. Occasionally "sports" with seven-pointed leaves are met with in Florida, even upon plants, most of the foliage of which consists of leaves with fewer divisions, but growth in sub-tropical latitudes seems to eliminate the poisonous property entirely, or to reduce it below the danger point, as cases of poisoning from consumption of the root by either man of beast are wholly unknown in the state.

CHARACTERISTICS.—The plant is a luxuriant, many-branched shrub, covered with dark green, reddish veined or stemmed, palmately divided leaves almost entirely concealing the branches to which they are attached. These branches contain a soft, white pith, and possess nodes from which the next generation of plants is obtained, as is the case with sugar-cane, the plant flowering, but rarely maturing seed in Florida.

The main stems are often over two inches in diameter at the ground, and thrifty plants usually attain a height of from five to six feet with a spread of about the same dimensions, so that planted in hills four feet apart each way the intervening spaces are entirely filled, and passage between the rows late in the season is difficult. The roots, or more properly, the under-ground stems, are attached to the main stock and are usually from one to three inches in diameter and from one to three feet in length as the result of a single year's growth. It is these roots which give the plant its value and furnish its usable part. The y consist of a pure white solid tissue, harder and drier than potatoes, or other so-called root crops, and have a very high content of starch. They are covered with a thin, reddish-brown fibrous bark, easily removed by washing or light scraping, and it is this bark which, in the tropical variety, contains much of the poisonous ingredient. This constituent is volatile, and, therefore, is wholly removed by cooking.

SOIL AND CLIMATIC CONDITIONS.—Cassava grows in all parts of Florida with all the ease and aptitude of a nature. It thrives best, however, on moderately fertile, sandy soils, and is perfectly adapted to the vast areas of pine lands constituting so large a portion of the state. It possesses great drought-withstanding power, very much surpassing corn in this respect.

So far as latitude is concerned, no positive limits may be assigned to the area of its successful growth. It will, to the writer's personal knowledge, thrive as far north as Macon, Ga., and might be grown to advantage over a large part of both of the Carolinas, Georgia, Alabama, Mississippi, Louisiana and Texas, with the probability of successful cultivation in parts of Arkansas, Oklahoma and Indian Territory. It requires a long season for its full development, and is very sensitive to frost, as much so as is the tomato. The limits of its possible habitat may, perhaps, be best described by the statement that cassava will thrive wherever the soil is adapted to its development and a period of seven months of immunity from killing frost is assured, or where danger from the spring frosts ceases with the middle of March and liability to the autumn frosts does not occur until after the middle of October.

PREPARING THE SOIL.—Land on which cassava is to grow requires thorough plowing. If the sand or loam has become compacted below the usual depth of plowing, or if the stratum of clay approaches the surface, the sub-soil plow should be resorted to, or if unavailable, the long "bull-tongue" should follow the turn-plow or scooter. Thorough pulverization should be secured by the use of the harrow following the plow. This is particularly important, as the young plants start slowly, and cannot be so roughly treated as is the case with corn, where the harrow may be used several times between planting and the time for the first plowing or cultivation.

The crop should be worked both ways, and should, therefore, be planted in squares, four feet each way. This is most simply effected by running furrows at right angles with turn-plow or scooter, and dropping the seed at the places where these furrows cross each other.

FERTILIZING.—A common belief among growers of cassava is that the demands of this crop upon the soil for fertility are comparatively small. As a cnsequence of this general opinion, the practice of most growers has been to apply very moderate quantities of fertilizers, the usual application being from 250 to 300 pounds of common high-grade commercial fertilizer per acre. At DeLand, where some 500 acres were grown during the past season the opinion is frequently expressed that the minimum quantity of fertilizer mentioned above is more economical in its results than any heavier fertilizing has been.

To put the correctness of this prevailing supposition to a test and at the same time shed as much light as possible on the plant-food requirements of cassava, a series of plot fertilizer experiments were conducted by us during the past season. The location of the plots gave conditions as nearly equal as any to be found on the station farm. These plots consisted of one-fifth of an acre each. Eight different experiments were included in the list, and one trial was made in duplicate on two different plots as a test of the equality of the conditions on the different plots. The fertilizer adopted as a standard of comparison was the same as that on our regular field crop, which experience had demonstrated as being economical and satisfactory in results. This application I designated as the "normal," and all the other applications on the different plots were simply modifications of one or more of the constituents of this "normal" fertilizer, which consisted of 125 pounds of acid phosphate, 150 pounds of cotton seed meal and 75 pounds of muriate of potash per acre.

This mixture, therefore, contained 18 pounds of phosphoric acid, 10 pounds of nitrogen and 36 pounds of potash. These quantities converted into the expression more familiar to most consumers of fertilizers, show the following percentage composition of the mixture:

Phosphoric Acid.......	5.14	per cent.
Nitrogen...............	3.	per cent.
Potash..................	10.	per cent.

The plots were numbered cosecutively from 1 to 9 inclusive, the character of the application to each plot having been as follows:

No. 1, check plot with no fertilizer.

No. 2, double the "normal" application.

No. 3, one and one-half times the "normal" application.

No. 4, the "normal" application adopted as a standard of comparison, consisting of acid phosphate 125 pounds; cotton seed meal, 150 pounds; muriate of potash, 75 pounds, an aggregate of 350 pounds per acre.

No. 5, "normal" phosphoric acid and nitrogen, but only one-half the "normal" amount of potash.

No. 6, "normal" nitrogen and potash, but only one-half "normal" phosphoric acid.

No. 7, "normal" phosphoric acid and potash, but only one-half "normal" nitrogen.

No. 8, a duplicate of No. 2, to test the equality of soil conditions on the different plots.

No. 9, a duplicate of No. 8, except that the total quantity applied was divided into three equal parts, applied at three different times.

It is believed that this series of fertilizer tests furnishes a basis for determining the actual food requirements of the cassava crop, as well as the economical application, since it provides for two total applications of one and one-half and double the "normal" application respectively, and for applications in which each of the single constituents is diminished by one-half, as a result of which the question as to whether one or more of the constituents in the "normal" fertilizer could have been present in smaller quantities with equal benefits to the crop, and necessarily reducing of the price of the total application should be answered.

For convenience of comparison the results of the experiment are presented in Table I:

TABLE I.

FERTILIZER EXPERIMENTS WITH CASSAVA.

No. of Plot.	Acid Posphate per plot.	Acid Phosphate per acre.	Cotton Seed Meal per plot.	Cotton Seed Meal per acre.	Muriate of Potash per plot.	Muriate of Potash per acre.	Rate of Fertilizing.	Yield of Roots per plot.	Yield of Roots per acre.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.
1	......	......	...	......	......	......	Check Plot.	1,484	7,420
2	50	250	60	300	30	150	2 Normal.	2,086	10,430
3	37½	187½	45	225	22½	112½	1½ Normal.	2,296	11,480
4	25	125	30	150	15	75	Normal.	2,702	13,510
5	25	125	30	150	7½	37½	½ Potash.	3,010	15,050
6	25	125	15	75	15	75	½ Phos. acid.	2,856	15,080
7	12½	62½	30	150	15	75	½ Nitrogen.	2,450	12,250
8	50	250	60	300	30	150	Dupli. No. 2.	2,695	13,475
9	50	250	60	300	30	150	Dupli. No 8.	2,548	12,740

*Check Plot—No Fertilizer.

Several important facts seem to be demonstrated as results of this series of experiments. It must, however, be borne in mind that a single year's trial is not sufficient for a positive demonstration of facts or laws, but several of the indications are so noticeable that deductions therefrom seem to be reasonable, and may form the basis of practice until further investigation shall have increased or diminished their strength.

FIRST.—The average yield of cassava on the eight fertilizer plots was 12,979 pounds, equivalent to almost exactly six and one-half tons per acre. The smallest yield was 10,430 pounds, while the heaviest was 15,080 pounds, or slightly over seven and one-half tons. Heretofore a fair average crop has been considered to be from four to five tons, yet our average of six and one-half tons during a very exceptionally, indeed, phenomenally, bad season, demonstrates that even the poorest soils of the state—few are poorer than the soil of the station farm—will produce much heavier crops of cassava than has been usually supposed, and that with more thorough study of the fertilizing requirements of the crop, the yield upon plots 5 and 6 seem to demonstrate that very considerably larger returns may be reasonably expected.

SECOND.—Comparison of plots 2 and 8, which received identical treatment but produced respectively 10,430 and 13,475 pounds of roots, shows that there is a possible variation between the different plots of 3,045 pounds per acre, and that as a consequence, differences between the various plots aggregating less than one and one-half tons per acre may have resulted from natural causes and must, therefore, not be considered in drawing conclusions from the actual yields upon the different plots.

THIRD.—The next important fact apparently demonstrated by the experiment is that increasing the "normal" application of the fertilizer does not increase the yield of the crop. In other words, that the "normal" fertilizer is the heaviest application which can be economically made to the cassava crop on such soils as ours. This is demonstrated by plots 2 and 8, each of which received double the amount of fertilizer applied to No. 4, but which gave an average return of 11,952 pounds as against 13,510 pounds upon plot No. 4, with the "normal" fertilizer, or only one-half the amount of plant-food supplied to the other two plots.

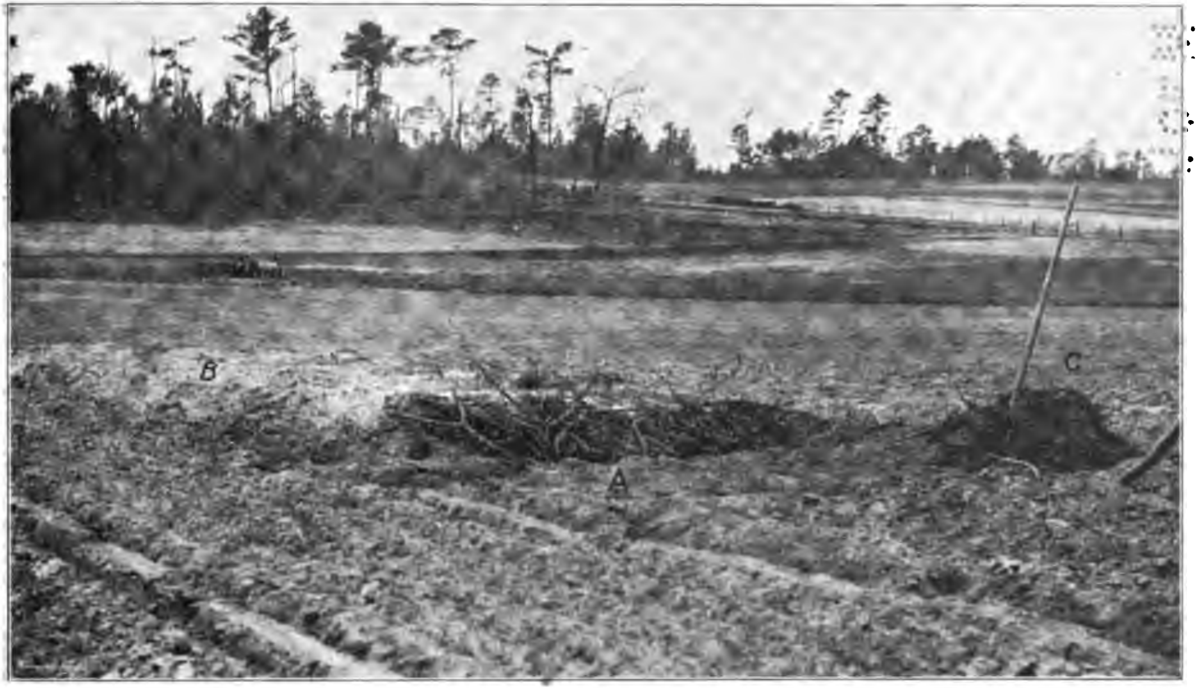
FOURTH.—Plots 5 and 6 each show important facts, viz, that reducing the "normal" amount of potash by one-half, as in No. 5, and phosphoric acid, as in No. 6, does not diminish the amount of cassava. Indeed, so far as actual yields go these are the two best plots in the series. The actual increase in yield, however, on each of these two plots is considerably less than the possible variation from natural differences, and should, therefore, not be considered as probably the result of the use of less phosphoric acid and potash in the applications made to these two plots. The result, however, is sufficiently marked to justify the conclusion that the "normal" application contains an excess of each of these mineral plant-foods and that the proportion of these two ingredients might, with advantage and economy, be decreased one-half from the '"normal" standard.

FIFTH.—The results upon plot No. 7, seem to demonstrate that the amount of nitrogen in the "normal" application cannot be advantageously reduced, since the yield upon plot No. 4 was 13,510 pounds, while that on plot No. 7, where one-half of the nitrogen was omitted, was but 12,250 pounds.

SIXTH.—These different results lead to the natural conclusion that the most economical fertilizer for soils like ours at the station should furnish the crop with the equivalent of 62½ pounds of acid phosphate, 150 pounds of cotton seed meal and 37½ pounds of muriate of potash, making a total application of 250 pounds, having a percentage composition of approximately 2.6 per cent. phosphoric acid, 3 per cent. nitrogen and 5 per cent. potash.

These results are really a striking corroboration of the prevailing practice among the largest and most successful growers in the state.

SEVENTH.—One other fact demonstrated by these fertilizer experiments is the apparent uselessness of dividing the total fertilizer application into several parts to be applied at different times as protection against the possible loss of nitrogen, but the same could all be used by the crop. Plots 8 and 9 apparently prove that there is no such loss, and that the total amount of nitrogen applied is actually assimilated by the crop. In this connection, however, it should be remembered that though the small fertilizer application of 250 pounds appears most satisfactory and economical, it offers no protection



CASSAVA SEED-BED

A. Canes. B. Covered Bed. C. Straw used as first covering.

against soil deterioration, as it supplies only the apparent demands of the crop for a single season, and that, therefore, where rotation, green manuring, or other method of soil recuperation is not practiced, a heavier amount of fertilizer would probably in the end be profitable.

METHOD OF APPLICATION.—The entire amount of fertilizer to be used should be applied at one time, and, probably, broadcast and cultivated in before planting. Where local conditions or lack of suitable tools necessitate a different method, however, the fertilizer may be distributed in the furrow and mixed with the soil by the scooter before the seed-cane is planted.

PLANTING AND CULTIVATION.—The seed, preserved through the winter as described on page 17, begins to sprout and grow with the advent of warm weather, and must be planted before it loses its vitality in this way. This will usually occur in March. The seed-canes are cut into sections about four inches in length, which is best effected by means of sharp knives, hatchets, or, best of all, pruning shears, by which the most rapid and best work is effected. The pieces must be dropped in the furrow by hand; where the check system is followed, the intersection of the furrows mark the places for dropping. The most satisfactory results are secured by dropping two pieces in a place, and the workman, by stepping on the dropped pieces, facilitates their subsequent covering. The covering is easily accomplished by the turn-plow, or best by the cultivator with all the teeth removed except the rear teeth on each side, which should be shovels, and set as closely together as possible. An implement producing similar results is easily improvised with a pair of "bull tongues" and a common Dixie plow stock. These teeth should be made to straddle the row and throw the soil toward each other, thus perfectly filling the furrow and covering the seed-canes lying therein.

The season's cultivation and working of the cassava crop is simple. The first cultivation may be deep, and with a plow, if preferred. After-cultivation must be shallow, and with a cultivator or wide sweep. In either case, the implement should be run as near the surface as possible, both because of the effect on soil moisture and because many of the roots grow horizontally and very close to the surface. The cultivation practised with corn is equally adapted to cassava, and three or four workings will be sufficient, notwithstanding its long growing season. When the plants reach well out into the space between the rows and shade the ground well, all cultivation may cease and the crop be considered as laid by. At the time of the last cultivation, which will usually occur about the first of August, a single row of cow-peas may advantageously be sown in the middle of the rows.

HARVESTING.—The nature of the plant necessitates hand-harvesting, but it possesses two saving graces, which render the task comparatively easy. First, it thrives best on light, sandy, dry soils, in which its roots do not have a very tenacious hold, and second, so many of these roots grow near the surface that no great difficulty is experienced in removing them in a body from the soil. The work is best performed by two men on opposite sides of the row. The stems should have previously been cut off with hoes about four to six inches above the ground after the appearance of frost, or the general yellowing of the leaves shows that growth is at an end. The remaining stubs of stems furnish a hold by means of which the entire root system is raised from the ground. If any plant possesses a specially tenacious hold on the ground, a little loosening by shovel or spade thrust under one side of the plant, will accomplish its release. Roots occasionally become broken off in the ground, but these are secured without difficulty by means of shovel or spade.

TWO CASSAVA ROOTS, WEIGHT THIRTY-ONE POUNDS.

The roots must be kept in a dry and reasonably cool place or they are apt to deteriorate after a few days' removal from the ground. As the ground on which cassava grows seldom freezes, the crop is best stored where it grew, and only harvested a few days previous to actual use.

The common belief, however, oft repeated and reiterated in print, that cassava cannot be preserved out of the ground, but that immediate use is necessary, I have proved to be founded on entire error. Last season I kept roots in the station office from February until July, and then submitted them to an examination by glucose experts from Chicago and Buffalo, who pronounced them to be in perfect condition for glucose or starch manufacture. Broken or mutilated places on the roots soon become covered with dark mold, but the growth is extremely superficial and in no way interferes with the character of the root or its constituents.

In South Florida the plant is perennial though it loses its leaves and some of its stems during winter, but with the advent of spring it sends out new shoots, and last year's roots begin to make new growth, so that the entire crop is not necessarily harvested. With even these conditions, however, it is probable that annual planting is more profitable than to attempt to secure more than a single season's growth on the roots.

In this connection it is well to call attention to the fact that the actual yields with our crop were considerably above the usual average yield, yet they fall very much below frequently reported yields. These latter are as a rule mere estimates. The illustration given of two roots was supposed to have been made from average samples, and at this rate of 15½ pounds per hill, the yield per acre would have been 30,830 pounds, or something over 16 tons. The real yield, however, was 6½ tons, a difference which should be remembered when claims of preposterous crops of cassava are made public.

PRESERVING SEED.—The entire above-ground growth of the plant, except its leaves and tip stems, may be preserved for seed. The stems are trimmed by hand, the leaves and tips being broken off and then laid upon a dry piece of ground, preferably freshly plowed. The butt-ends of the stalks should be thrust into the ground and then a second layer be placed over them, butts also in the ground, and so the pile, or bed, should be continued, layer on layer, like the shingles of a roof, till, for convenience sake, the bed is large enough. The cane should then be covered with straw, hay, or moss, and this with a light layer of soil. In extremely dry weather the addition of a little water to the beds is advisable, but our winter rains are usually ample for the needs of the seed-cane, and our experience at the station is that a superabundance of moisture is more dangerous than dry weather, as rotting of the bed is more common than its drying out. Neither extreme, however, is frequent, and the seed may be expected to pass the winter in good condition with reasonable certainty.

The complaint frequently met with of difficulty in obtaining a full stand of cassava, I am confident, results from ftilure to follow these simple rules for the proper preservation of seed canes.

II

USES OF THE CROP.

The uses to which any crop may be put must depend chiefly on the composition of the material in question. With cassava not only are the uses to which it has already been devoted the result of its composition, but new uses suggested for the crop depend almost exclusively upon this composition. Cassava is distinctively a starch-forming crop, and belongs essentially to the carbohydrate division of foods. It is, therefore, a characteristic fat-former, and when properly used, becomes one of the most economical heat and fat-forming articles of food for all classes of animals, human beings included.

The chief value which the crop possesses lies in the fact of the cheapness with which fat-forming material may be produced in this shape, and its economical position depends upon the recognized desirability of producing at home the greatest possible supply and variety of foods for home consumption. Before entering into details of the utilization of the crop, therefore, it becomes necessary to minutely examine its composition as determined by chemical analysis. This feature of our work is essentially new, there having been heretofore, so far as I am able to ascertain, but one analysis of cassavá published.*

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* Bulletin No. 44 published by Chem. Div. U. S. D. A., 1894.

TABLE II.

ANALYSES OF STATION CASSAVA.

	FROM PLOTS 6 & 7			FROM PLOT 8.			AVERAGE
	Dry Root.	Natural Root.	Water Free.	Dry Root.	Natural Root.	Water Free.	Water Free.
	Pr ct.	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Per cent
Water	5 18	66.02	....	5.16	67 37	....	....
Protein.*	2.38	0.85	2 51	2.53	0.86	2.67	**2.59**
Fat	0.55	0.20	0 58	0.50	0.17	0.52	**0.55**
Resins, Alkaloids, etc.†	0.35	0.13	0.37	0.30	0.10	0.31	**0.34**
Amids and Sugars‡	16.35	5.86	17.24	15.83	5.44	16.68	**16.96**
Crude Fiber	4.81	1.73	5.08	4.79	1.64	5.05	**5 06**
Starch	68.50	24 53	72.24	68.56	23.62	72 32	**72.33**
Ash	1.88	0.68	1.98	2 33	0.80	2.45	**2.21**
Potash	0.76	0.27	0.80	0.96	0 33	1.01	**0.90**
Phosphoric Acid	0.24	0.08	0.25	0.23	0.79	0.24	**0.24**

***Calculated from total nitrogen.**
†Ether extract.
‡Alcohol extract.

The first important fact shown from the above analysis, is that cassava contains a larger amount of non-nitrogenous extract matter than is found in any other crop. This matter is composed largely of starch, of which it contains much more than either the Irish or sweet potato. A very considerable quantity of sugar, however—about 3 per cent.—is also included in this material. Cassava, therefore, presents marked characteristics of both potatoes and sugar beets, but contains very much more total food, because of its greater solidity and smaller content of water.

That cassava is not a perfectly balanced food, that is, does not contain flesh-forming and fat-forming materials in the relative proportions necessary to secure the best posible results from its use, or the greatest economy from its feeding is apparent. On the other hand, no food, with the possible exception of fresh milk, exists in these per-

fect proportions; in each one or the other class of constituents predominates "Man cannot live by bread alone," is a fact as scientifically correct as it is a recognized expression of Divine wisdom. Man must have beef or eggs with his bread; beans or peas with his pork, and chickens with his potatoes, if either is to be fully utilized and the greatest possible amount of nutriment be secured.

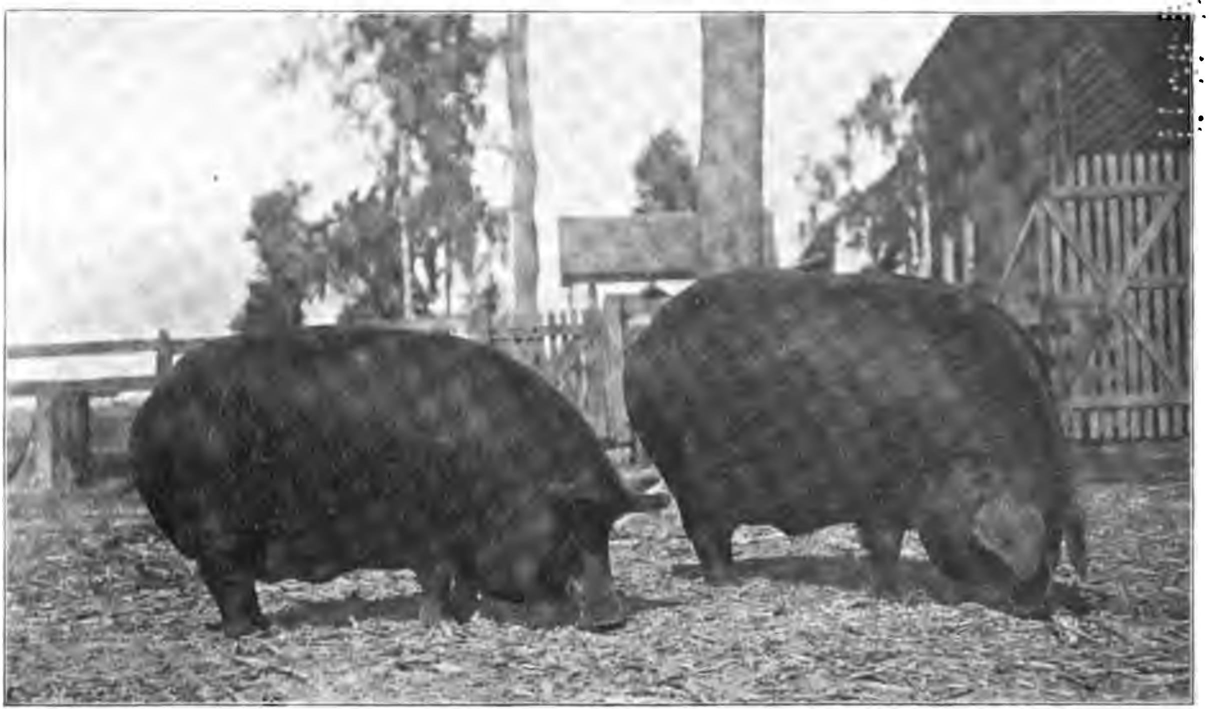
So with hay the animal requires bran, corn-fodder with cotton seed meal, and with cotton seed hulls, pea vines or velvet beans are required if the full value of either is to be secured to the animal.

It is unquestionably true, however, that cassava, all things considered, comes nearer supplying a perfect ration for farm stock than any other concentrated food produced upon Florida farms.

That the composition of other foods may be readily compared with that of cassava and that, therefore, the data needed for the most economical utilization of Florida feed-stuffs may be available, Table II. has been prepared, giving the nutritive constituents of all distinctively southern feed-stuffs, based mostly on our own analyses, and in each case upon the form of material in which we Floridians are accustomed to use the food.

The importance of this latter condition is illustrated by the case of pindars, which, though frequently analyzed, are with us always fed in the field, being harvested by the hogs; all analyses made under any other conditions. So far as the writer is able to learn no other analysis of this crop is so stated as to be of assistance to any Florida farmer desirous of knowing its composition of this crop that he may intelligently supplement it with other food in the hope of securing better and more economical results.

Before actual consideration of some of the details of this table an attempt to apply them to the problem of the rational feeding of Florida stock, a good demonstra-



HOGS FED ON CASSAVA. DRESSED WEIGHT OF THE HEAVIEST 538 POUNDS.

tion of the possibilities of the use of cassava as a feedstuff is furnished by two simple feeding experiments conducted at the station—one with pigs and one with cows.

A.—EXPERIMENT WITH PIGS.

This was a comparison of cassava, corn, chufas, ground-peas and pindars in the fattening of pigs. The experiment covered a feeding period of seventy-five days, terminating January 14th, 1896. The details of the experiment were carefully carried out by Mr. John F. Mitchell, the station foreman, to whose fidelity and care I am indebted for the data now made use of. The basis of the experiment was the quantity of each of the materials fed which the different lots of pigs would consume. The pigs were all of the same breed—grade, Duroc-Jersey—and as nearly as possible of the same weight and age. It was believed better to have the pigs of each lot of about the same size, rather than to even up the weights of the different lots by having in any single lot individuals with considerable differences which might have resulted in quarrelling and the depriving of the smaller member of the feeding lot of his full ration. All pigs of each lot were clearly marked, so that there was no possibility of mixing or mistake at any stage of the experiment.

The station was not equipped for digestion experiments and it will be seen that one very important factor was omitted in the scheme of experiment, viz: the actual value of the food consumed by each lot of pigs, which would have necessitated the weighing of the food consumed. This data would have furnished the only possible clue to the cost of the gain made by the different pigs, and hence would have determined the economy of feeding.

This precaution is necessary since it is quite possible that the pigs showing the greatest gain, and thus the largest gross return from the food consumed, may have been fed on comparatively expensive food, so that the increased weight might not pay for the increased cost of the food; in which case pigs showing a smaller increase in weight, might have really eaten so much less value in food as to make their actual gain cost less per pound, so that the food given them might have well been the most economical in net returns. This is an exemplification of the well known fact that the heaviest hog, or the largest steer is seldom the most profitable animal.

The important factor of the amount of food consumed, I have supplied as well as possible from my own record of the amount of cassava or corn consumed by several pigs of the same breed, age and condition during the same time of year, so that though not the identical individuals in the original test the averages furnish reasonably correct data for determining the relative values of the quantities of food consumed by the corn and cassava-fed pigs in the earlier experiment. Thus, so far as practical farm purposes go, we have a basis for estimating the actual cost of the meat produced by each kind of food and can thus determine the relative economy of corn and cassava as hog foods.

The results of this experiment reduced to the averages and totals of each group or lot, numbered numerically, are presented below in

TABLE III.

CASSAVA COMPARED WITH OTHER FOODS IN FATTENING HOGS.

Kind of Feed.	Total wt. of 3 pigs at beginning of period.	Total wt. of 3 pigs at end of period.	Gross gain.	Average gain per pig.	Percentage of gain per pig.	Estimated amount of food per day consumed per pig.	Estimated cost per day of food consumed per pig.	Cost per pound of gain.	Actual profit pr pig on food consumed, estimated at 3 cents per lb. for grain made.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	$
Cassava	167	326	159	53	95.2	2½	0.75	1.04	1.07
Corn.............	247	424	177	59	70.0	2¼	2.41	3.06	—.35
Chufas............	223	254	21	21	7.0				
Pindars...........	202	251	49	16	24.2				
Goobers...........	173	231	58	19	32.2				

The important facts presented in Table III, as the results of the series of feeding experiments, seem to be as follows: *First*, the percentage of gain in weight as the result of feeding five different lots of pigs, on as many different materials, for a period of 75 days, places the foods tried in the following order of merit: Cassava, corn, goobers, pindars and chufas. the latter standing at the bottom of the list, with the percentage of gain to the pigs fed upon it only 7 as against 95.2 for cassava, indicates that this crop should be excluded from the list of economical hog foods. *Second,* Corn, which is the standard fattening food of the Western Hemisphere and the material on which probably 95 per cent of the fat hogs of American markets are finished off preparatory to slaughtering, makes but a poor showing as compared with cassava, though it ranks second in the list of foods tried, its percentage gain being 70 as against 95.2 with cassava. The difference between the two rates of gain

70 and 95.2, is 25.2 per cent. in favor of the cassava pigs. The actual comparative gain, however, is considerably greater since 25.2 is 36 per cent. of 70, and therefore, the real difference in value between these two foods is 36 per cent. in favor of the cassava. In other words the experiment shows that pigs fed on cassava will make 36 per cent. more meat during a given interval than if fed upon corn. A different statement of the same fact is, that there is more than 1-3 more profit from the feeding of cassava than corn, in fattening pigs, where the cost of producing the two foods is the same. When it is borne in mind, however, that the actual cost of producing cassava, food value for food value, is very much less than with corn, the advantage of the former appears still greater, and there can be no question of the place of cassava as "a money crop." *Third,* The daily cost of these two foods as nearly as it can be estimated was 0.75 of one cent per day each, for the cassava fed pigs, and 2.40 cents each for the corn fed lot. The total cost therefore, of the amount of food consumed during the 75 day period was $5.52 for the cassava pigs and $18.07 for the corn fed lot. This amount divided by the gain in weight for each lot shows that the actual cost per pound of the meat made from the food consumed was 1.04 cents for the cassava and 3.06 cents for the corn fed pigs.

The actual market value of the live pork and of corn at the time the trial was in progress being known, have been used as a basis for the calculation. As to the basis with cassava however, no actual market value then existed. Where starch factories have, however, been established in the state $6 per ton is paid for the roots, and this has, therefore, been adopted as the standard of value, although as a matter of fact, our own experience shows that the crop can be grown and harvested at $14.00 per acre, which with our average yield makes the actual cost of the cassava only about $2.00 per ton, on which basis the relative profit of feeding the same to pigs, would have been three times greater than appears in the estimates of the table.

With these actual facts accepted, can there any longer be doubt that cassava converted into meat, bacon, lard and hams as finished products, for which the supply never equals the demand, is indeed a "money crop."

As further evidence that the experiments were conducted under normal conditions, and also that the advantage shown for cassava as a fattening material is not possessed by the hog feeders of any other section of the country, I venture to present for comparison the results of pig-feeding trials made at representative experiment stations, North and South, at the very time that these trials were under way in Florida. Bulletin 82 of the Alabama station shows that with their experiments in the feeding of four different lots of pigs upon as many different rations, the average cost of the gain in live weight by the pigs being fed was 3.51 cents per pound. The annual report of the Mass. Hatch Experiment Station for 1896, shows that the average cost of the gain in live weight made by pigs under experiment was 2.88 cents per pound. This, too, where a chief constituent of the ration was skimmed milk, valued at 0.15 cents per pound and supposed to be the cheapest of all hog foods. The annual report of the Vermont Experiment Station for 1896 shows that the average cost per pound of increased live weight with four different lots of experimental pigs was 3.72 cents per pound.

The average cost of the gain made at these three different stations was 3.37 cents per day, or 3.24 times the cost per pound of the gain produced by us through the feeding of cassava. The Vermont report further specifies that the average profit per pig fed during the period of trial was $0.50. This, too, during a period of 106 days as against our profit of $1.07, made in the period of 75 days with cassava. A further important consideration is the fact that in each of the cases specified the profit was figured on a basis of $0.05 per pound, live weight, for pork, while our estimates are based upon the low market valuation of $0.03 per pound.

These certainly are important facts and worthy of careful consideration. They form a simple demonstration that cassava properly used and fed must certainly be a very much more profitable crop than any other crop which can be converted into hogs or hog-products.

B.—EXPERIMENT IN FATTENING BEEF ON CASSAVA.

Several animals were fed as a test of the effects of cassava, in keeping animals in condition and of restoring poor animals to proper condition. Several animals have satisfactorily been fattened with cassava as the sole fattening food used. Only one animal, however, was actually experimented with for a definite fattening period, and the result finally tested by slaughtering of the animal.

The Station has not been properly equipped for feeding experiments, and no claim is made to scientific method; it is believed, however, that the case offers results of practical value to Florida farmers. At the time the feeding was begun, no tests whatever had been made of the digestibility of cassava, though now a beginning has been made along this line. The particular bearing of this deficiency is the fact that during this feeding trial we possessed no data for determining the real nutritive ratio of cassava, and were, therefore, prevented from arranging a scientifically correct ration or combination of foods. The tests, therefore, were really simply tests of the question as to whether cassava could be used in the same way that corn is so nearly universally used in the corn belt of the Central West, in preparing steers for the Chicago and Kansas City markets.

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DRESSED BEEF PRODUCED BY CASSAVA.

There hay and cornstalks form the coarse fodders and corn fed in cribs is the sole fattening reliance. In the test made by us dry hammock pasture grass furnished the coarse feed, but cassava was substituted for corn as the fattening material, supplemented by a little cottonseed meal to improve the nutrative ratio and supply the protein actually present in corn. Twoanimals were included in the experiment, but as one of them was needed for future breeding purposes, the record and slaughtering test is confined to one animal. This was a common Florida cow of the larger class, though at the time of the beginning of the test, she had received no food except such as she picked up for herself on the woods range for some months. She was ten years old, and thin to the point of emaciation. To meet Florida conditions hammock pasture, supplemented with an occasional feeding of pea vine, velvet bean, or crab-grass hay, furnished the coarse fodder, and no shelter was supplied or needed during the feeding period, which included 75 days, ending February 19, 1899. Although the experiment is adapted to local conditions, and is believed to possess practical usefulness for range cattle owners, the actual ration consumed cannot be accurately determined. The animal in question was fed all the cassava she would consume, and the amount thus fed to her averaged 12 pounds per day.

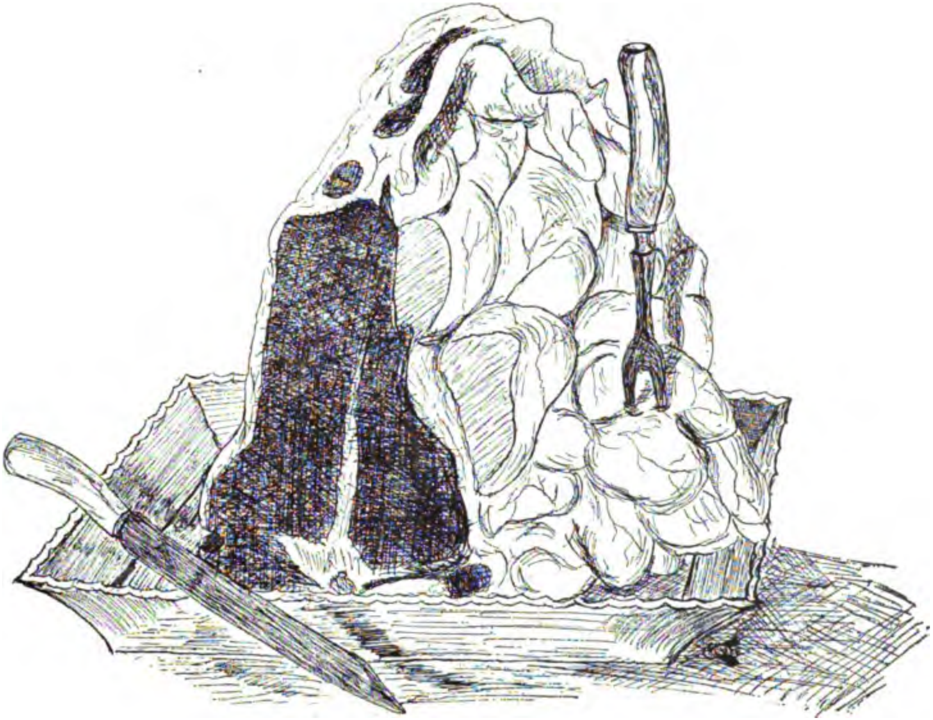
This was supplemented by two pounds of cotton seed meal, added as a source of protein, and the actual market value of the materials thus consumed is incorporated in the table in which the results are presented.

FATTENING BEEF UPON CASSAVA.

Live weight at beginning of period	450 pounds
Live weight at end of period	726 pounds
Gross gain	272 pounds
Dressed weight at end of period	502 pounds
Amount of cotton seed meal consumed per day	2 pounds
Amount of cotton seed meal consumed for period	150 pounds
Amount of cassava consumed per day	15 pounds
Amount of cassava consumed for period	1,125 pounds
Value of increased weight	$11.04
Cost of feed consumed	2.62
Profit	$8.42

The result of the feeding therefrom was an actual profit of 59.10 per cent. on an investment for seventy-five days. It is true, that no allowance was made for the labor involved in the care and feeding of the animal. This, however, was very slight and devolved upon a man having charge of 20 other animals who still found time for much additional labor. There can hardly be any question, therefore, that here again, cassava converted into the form of a human food becomes most decidedly "a money crop."

The results of this feeding test simply add other evidence to that already possessed by every cassava grower in Florida, as to its value as a stock food. The illustrations of the carcass of the cow, on which the test was made and of the porter-house cut of the same, together with a full page illustration of the Station dairy herd, taken at the time when cassava was the chief constituent of our daily ration, furnished ample demonstration of this fact.



A CUT OF ROAST BEEF.

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When it is recalled in this connection that there are over 200,000 head of range cattle in Florida,* and that hundreds of thousands of acres of superior pasture lands still remain unoccupied; further, that these cattle are nearer the Chicago markets than are the great ranges of Montana and Wyoming and possess an easy control of home markets and the new markets of Cuba, beside the advantages of direct water communication with the markets of Europe, the bearing of these facts becomes apparent.

Every beef animal in Florida can be put in the condition of western stall-fed cattle by the simple use of cassava at a mere fraction of the cost to the corn feeders of the West.

C—CASSAVA AS A RAW MATERIAL FOR MANUFACTURING PURPOSES.

It now becomes necessary to refer again to the composition of cassava, since its utilization in manufactures rests solely on the extraction of certain of its constituents.

There are two products for which this crop offers superior material, namely: Starch and glucose. The former, however, is the only product thus far actually commercially produced from cassava in this country. The starch supply of the world has heretofore depended upon potatoes and corn as raw materials. By comparing the actual yields of starch from these three raw materials in the factory we find that the average amount of starch produced is as follows:

Corn, 53 per cent.
Potatoes, 17 per cent.
Cassava, 20 per cent.

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* The census of 1835 gives the total number of cattle in the State as 469,425. Of these probably more than one-half are actually on ranges.

An acre yielding 40 bushels of corn would at this rate produce 1,187 pounds of starch, while an acre of cassava producing six tons would yield 2,400 pounds of starch. Two other conditions, however, must be considered as bearing upon the economy of manufacture, namely: The ing upon the economy of manufacture, namely: The relative cost of the raw material supplied in these different forms, and the cost of manufacturing of the finished product.

On the former point the market value of the three different sources of starch, and the amount of starch produced by each furnish a correct basis for estimating the relative value of each crop for this purpose. At the present price of corn and potatoes in Chicago, which is a starch and glucose producing center, and of cassava, at De Land, Fla., where the only cassava starch factory in the world is located, we find that unmanufactured starch in the form of corn, at 45 cents per bushel, costs 4 cents per pound, and the same material in the form of potatoes at 50 cents per bushel, costs the manufacturer 6 cents per pound, while cassava yields raw starch at 1 cent per pound.

It thus appears that cassava is to-day the cheapest known source of starch, costing at present market values of raw material only about one-fourth as much as its nearest competitor.

The matter of the relative cost is one for which no actual data exist, other than the experience of the single company, which has had two years experience in the manufacturing of cassava starch. The process, however, with the latter crop, is essentially the same as that in use by potato starch manufacturers, and, therefore, the higher starch yield and greater freedom from impurity should render the process less expensive and, therefore, more remunerative.

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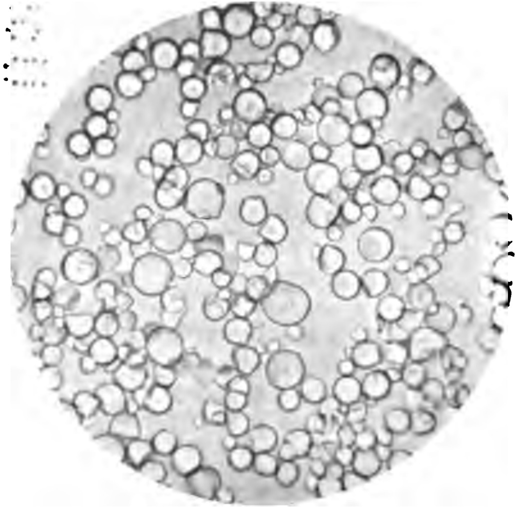
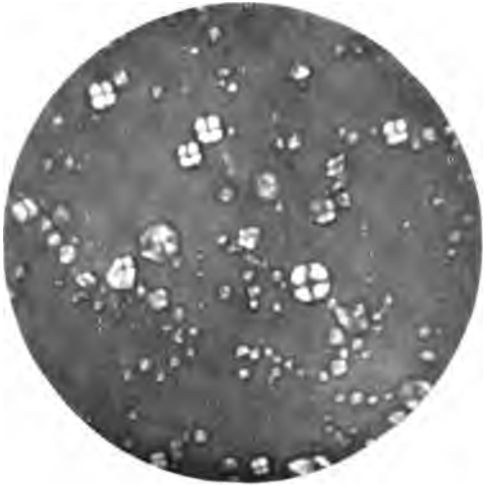


CASSAVA STARCH NOT POLARIZED.



SWEET POTATO STARCH POLARIZED.

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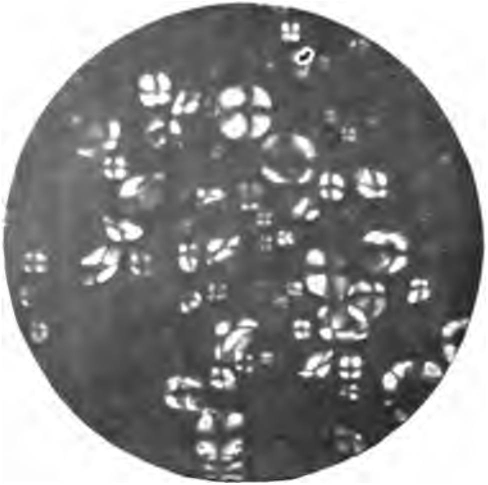
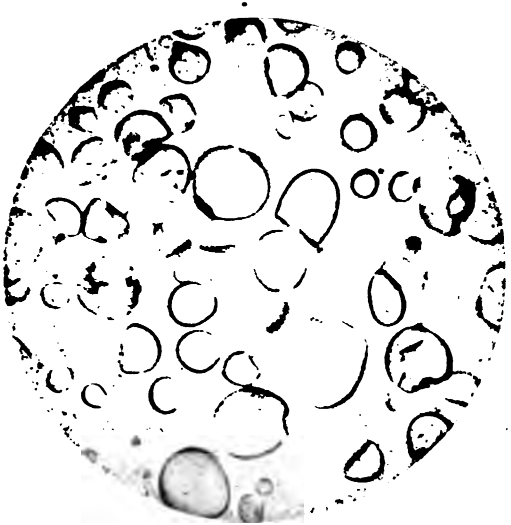


COONTIE STARCH POLARIZED.



COONTIE STARCH NOT POLARIZED.

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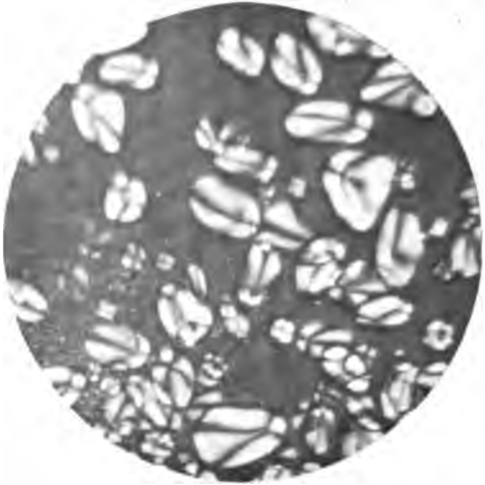
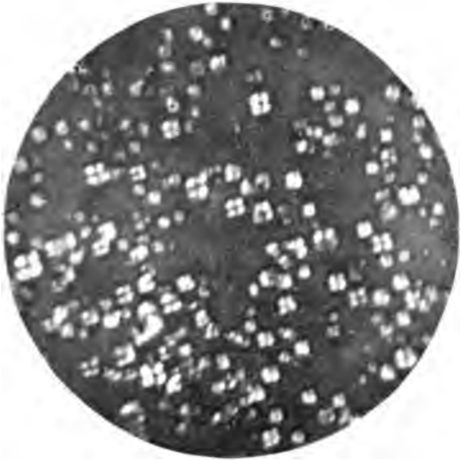


IRISH POTATO STARCH POLARIZED.



CASSAVA STARCH POLARIZED.

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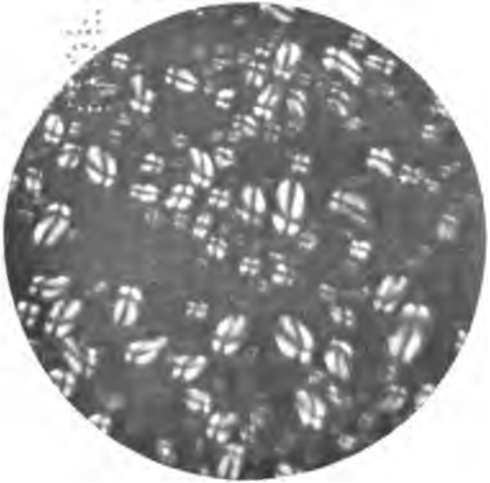
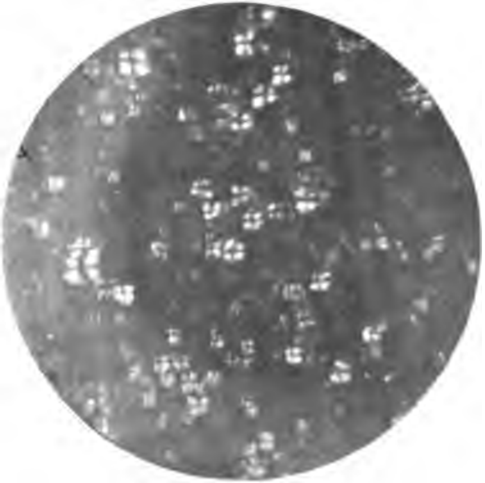


FLORIDA ARROW ROOT STARCH POLARIZED.



CORN STARCH POLARIZED.

In this connection it should be stated that cassava starch possesses certain properties not found in other starches, which seem to make it a favorite in the markets into which it has been introduced; so that there appears to be a steadily growing demand for the product at prices considerably higher than are quoted for other starches.

I may, with propriety add, that Mr. B. Remmers, managing director of the De Land factory, has extended to me many courtesies in connection with this phase of the industry, and placed information at my disposal which would not be expedient to make public, which, however, tends to strengthen my conviction that a very great future lies before this industry, wherever cassava can be successfully grown, and such experienced and competent technical control of the details of manufacture as are evidenced at De Land can be made available.

As the character of starches from different sources and the uses to which they may be put depend chiefly on the structure of the starch grain, and as these properties are the clue to substitutions and adulterations of different starch-containing materials, I have thought it desirable to introduce plates showing the formation of cassava starch as it appears under the microscope, in comparison with similar illustrations prepared from the other chief southern starch yielding crops.

The other product for which cassava offers inducements to manufacturers is glucose. The value of any raw material for this purpose depends on its content of starch, since the manufacture is chiefly a mere conversion into glucose by means of chemical action.

Not only, therefore, does the high yield of starch in cassava place it prominently before manufacturers as a probably new raw material for the great glucose industry, at present practically dependent upon corn, but, moreover, cassava contains two other constituents worthy of consideration in this connection, namely: its 3 per cent. of sugar against the 0.4 per cent. in corn and 1.68 per cent. of fiber, as compared with 2.20 per cent. of corn.

Both of these materials are convertible into glucose, and therefore, increase the possible output of the latter product.

Manufacturers are now considering the importance of these facts, and there is good reason for expecting the erection of at least two glucose factories in the near future, which will depend on cassava for their raw material.

With either starch or glucose manufactured from cassava, there must necessarily result very large quantities of waste products, which would be found valuable as either stock foods or for fertilizing purposes. In either case the chief of these would be the pulp which contains most of the cassava, except that its starch has disappeared.

The analyses of several of these products from the starch factory have been made expressly for this bulletin, and are now presented.

There is another product of cassava of considerable commercial importance, which, however, is at present produced only in tropical America, from the poisonous variety of the root. This is tapioca, the name for which is derived from the Indian name of the plant, mandioc, from which the term mandioca is applied to the product, which by transmission has received the commercial name of tapioca. Though this material has become so important an article of food, the cost of its production by the semi-civilized labor of South America is so much less than is possible under the labor conditions of Florida, that it is not probable that tapioca in the near future will become an important product of our State, except for family consumption.

The process of tapioca making is simple. The root is pealed and grated, and then macerated in water with constant agitation, or stirred until the starch granules are separated from the fiber, which latter floats on the surface of the water, and is thus removed; or, better yet, is strained from the water, by means of a sieve, through which the starch-milk, so called, passes, leaving the fiber behind. This starch-milk, which is simply an emulsion of starch, allows the latter to gradually settle, when the water may be poured off, leaving the semi-solid, moist starch behind. This latter is quickly dried by intense heat, the South American Indians dipping large iron shovels into the moist starch and then revolving them before open fires, the heat of which compels the starch to assume the granular semi-lucid appearance known as tapioca, in which form it becomes so desirable an article of food, an essential ingredient of so many wholesome desserts, and is so frequently eaten with little thought or knowledge as to origin or source of supply.

FEEDING CASSAVA.

As shown by the analysis in Table II, and as already several times stated on previous pages, cassava predominates in carbo-hydrate, or fattening constituents, and is nates in carbo-hydrate, or fattening constituents, and is lacking in protein, or flesh-forming constituents. That the crop, therefore, may be utilized to the best advantage, it becomes necessary to revert to the fact that animals are able to extract the greatest amount of nutriment from their foods only when these two constituents exist in certain relations to each other as to amount or proportion, and that this proportion, or relation, between protein constituents and carbo-hydrate constituents is termed the *nutritive ratio* of the food, and foods are said to possess a wide ratio or a narrow ratio, according as the proportion of carbo-hydrates is large or small. Cassava

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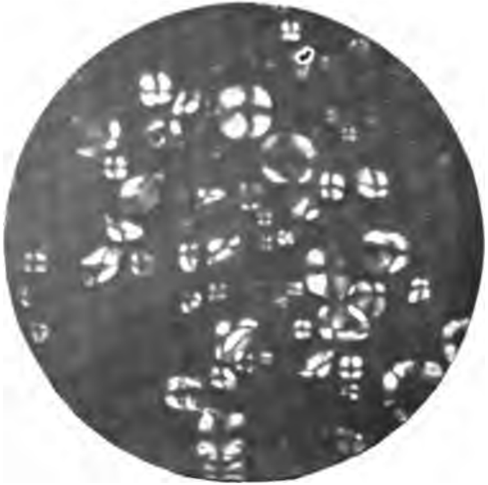
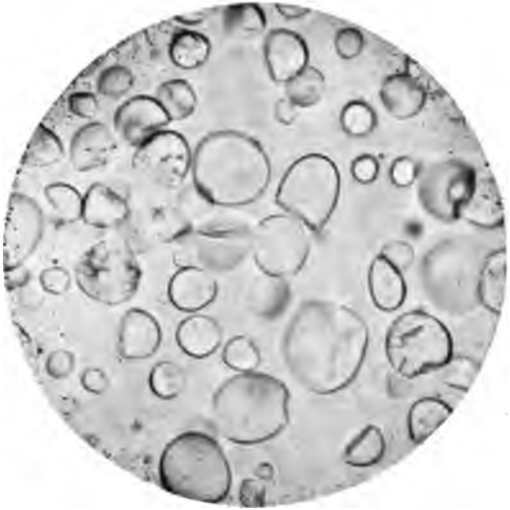


COONTIE STARCH POLARIZED.



COONTIE STARCH NOT POLARIZED.

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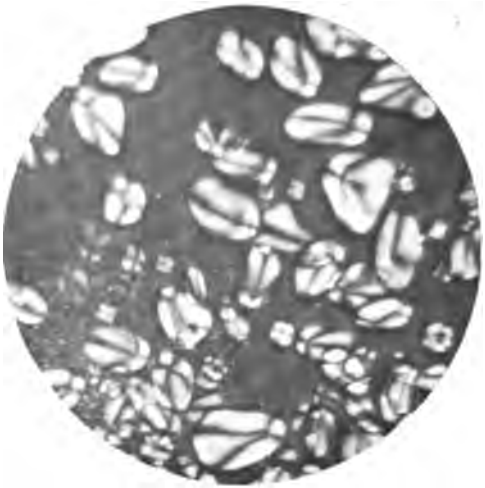
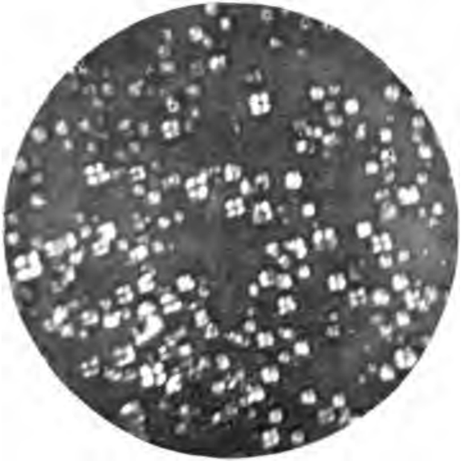


IRISH POTATO STARCH POLARIZED.



CASSAVA STARCH POLARIZED.

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range is available. The composition of dry winter range, or fall pasture grass, however, would not very materially vary from that of cured hay, so that in the arrangement of rations one may be substituted for the other as is most convenient or best suits the condition or surroundings of the feeder.

TABLE V.

FOOD CONSTITUENTS OF CASSAVA AND OTHER FEED-STUFFS.

	Moisture, Per Cent.	Ash, Per Cent.	Fat, Per Cent.	Fibre, Per Cent.	Nitrogen Free Extract, Per Cent.	Protein, Per Cent.	Nutritive Ratio.
Beggar-weed Hay	9.16	4.72	2.92	29.29	42.06	11.85	1:8.0
Cassava.............	66.69	0.74	0.18	1.68	29.84	0.85	1:36.0
Corn..........	10.60	1.50	5.00	2.20	70.40	10.30	1:10.3
Corn Fodder........	7.10	12.34	2.66	26.64	37.25	14.03	1:15.5
Corn Stover..	18.55	5.14	1.65	25.04	43.51	6.11	1:11.3
Cotton Seed........	9.92	4.74	19.45	22.57	23.94	19.38	....
Cotton Seed Hulls.	10.40	2.60	2.00	44.40	36.60	4.00	1:01.2
Cotton Seed Meal.	8.20	7.20	13.10	5.60	23.60	42.30	1:1.4
Cow-Peas...........	14.80	3.20	1.40	4.10	65.50	20.80	1:3.2
Crab Grass Hay...	10.65	9.37	2.25	27.62	41.89	8.32	1:10.0
Crowfoot Hay.....	11.73	7.40	1.58	20.75	50.21	8.32	1:10.0
Ground-Peas	14.94	1.97	28.08	33.16	16.18	20.41	....
Moss, Spanish.....	14.85	4.10	2.43	25.35	48.20	5.07	1:19.0
Oats..................	11.00	3.00	5.00	9.50	59.70	11.80	1:6.2
Oat Hay............	10.25	4.44	2.47	26.14	47.49	9.21	1:9.4
Pea-vine Hay-.....	14.05	8.41	2.87	19.80	42.17	15.68	1:4.0
Pindars........	14.47	2.64	29.69	14.01	16.36	23.24	....
Potatoes, Irish.....	78.90	1.00	0.10	0.60	17.30	2.10	1:11.8
Potatoes, Sweet...	71.10	1.00	0.40	1.30	24.70	1.50	1:21.4
Rice Hulls	10.40	13.20	0.70	35.70	38.60	3,60	....
Rutabagas..........	88.60	1.20	0.20	1.30	7.50	1.20	....
Rye Fodder, green	75.28	1.88	0.56	12.73	6.94	2.61	1:5.0
Sandspur Hay.....	15.30	4.00	1.90	27.88	45.66	5.26	1:16.0
Velvet Beans......	11.93	2.02	6.29	7.45	53.50	17.93	1:03.0
Wire Grass Hay...	10.15	2.95	1.72	28.71	53.19	3.28	1:28.0

DOMESTIC USE OF CASSAVA.

The composition as given in Table II, taken together with the results of the animal feeding tests recorded are sufficient to establish the wholsomeness and nutritive quality of the root.

Articles for human consumption, however, must possess one other property in order to recommend themselves to public favor, namely: flavor, or agreeable taste. This quality is, however possessed by cassava in a high degree.

Raw, it is pleasant and wholesome, though not especially desirable. It is far more palatable than raw Irish potatoes, though possibly not so much as carrots or flat turnips. Boiled or fried, it is a most nutritious substitute for either sweet or Irish potatoes. If boiled and then fried or baked, it is a decidedly desirable addition tothe variety upon any table. As an article of human food, however, it meets with chief favor when converted in to some form in which its characteristics are somewhat disguised. It must borne in mind that this is equally true of potatoes, pumpkins, flour and many commom foods. It may be briefly dried by means of the sun, oven, or evaporator, when sliced, cut with a root cutter, or even a spade, into thin slices, and then be reduced to flour by grinding. This flour is extremely nutritious, and a palatable substitute for all cereal flours and meals, and may be used either by itself or as an admixture with the products of ground grains. Bread, biscuit, batter cakes and all similar articles may be made from this cassava flour in the same way that other flour would be used.

The grated root assumes an appearance somewhat resembling cocoanut, and forms an excellent basis for pies and puddings. That its use may be facilitated, I have thought it advisable to incorporate several successful and favorite recipes for cassava dishes as patterns and suggestions of its proper preparation.

RULES FOR COOKING.

CASSAVA PUDDING.—Grate about one pound of cassava root, moisten with a little water, allow to stand 15 minutes; drain off one-half cupful of the starch solution settling at the bottom of the mass, add one pint of milk and three or four beaten eggs, one ounce of butter, with sugar and nutmeg to taste; bake like ordinary custard.

CASSAVA PULP PUDDING.—Take one cupful of grated cassava, three cups of milk, and boil five minutes; add three beaten eggs, one-half cup of sugar, and flavor to taste; bake one-half hour. This makes a pudding sufficient for six persons.

CASSAVA FRITTERS.—Grate one pound of cassava root, add salt to taste, and one teaspoonful of baking soda; soften with milk or water, and fry like any other fritters.

CASSAVA BATTER CAKES.—Mix one-half grated cassava with one-half corn meal or flour, add milk or water to desired degree of thinness, two beaten eggs, and fry like ordinary batter cake. Use baking powder or sour milk and soda, as with flour.

IN CONCLUSION the writer desires to acknowledge the cooperation and assistance rendered by the Biological and Chemical Departments of the Station and to return thanks to Profs. Rolfs and Miller for the same. I desire also to express my obligation to Mr. M. G. Donk for assistance in analytical work, and to Miss Lucia McCulloch for micro-photographic work.

H. E. STOCKBRIDGE.

BY-PRODUCTS FROM THE CASSAVA STARCH INDUSTRY.

The residues, or bi-products, resulting from the manufacture of starch and glucose from potatoes and corn, possess very material value for feeding or fertilizer purposes, indeed the bi-products from the glucose industry, where corn is the raw material used, are recognized as standard articles of cattle food. It is reasonable to suppose that the residue resulting from the manufacture of starch from cassava would possess value for this purpose and ânalyses have, therefore, been made of the bi-products from the DeLand factory which are here presented:

ANALYSIS OF WASH WATERS FROM CASSAVA FACTORY.

Water	99.64	per cent.
Volatile Matter	.30	"
Potash	.05	"
Phosphoric Acid	.03	"

ANALYSIS OF FINE CASSAVA PULP.

Water	93.23	per cent.
Volatile Matter	6.66	"
Potash	.16	"
Phosphoric Acid	.38	"
Nitrogen	.32	"

ANALYSIS OF COARSE CASSAVA PULP.

Water	89.14	per cent.
Volatile Matter	10.73	"
Potash	.06	"
Phosphoric Acid	.05	"
Nitrogen	.45	"

ANALYSIS OF CASSAVA BARK RESIDUE.

Water	79 60	per cent.
Volatile Matter	18.19	"
Potash	1.43	"
Phosphoric Acid	.12	"
Nitrogen	.75	"

The essential facts to which attention should be called in connection with the above analyses seem to be as follows:- That although these materials have already been utilized to some extent by farmers living in close proximity to the factory, if they are to become of general use and value, their physical condition must be materially changed as they contain altogether too much water to render their transportation and use economical.

The amount of organic matter and of nitrogen found in the two different cassava pulps would indicate that, if properly freed from most of the water present, as could be easily done by draining or pressure, they would possess very considerable value as stock foods. This could not be otherwise, in view of the fact that the process of starch manufacture removes almost nothing but starch from the cassava and that even some two per cent. of the starch remains in the residue, the water content of which, however, has been very largely increased by addition of the water necessary for removing the starch from the root.

The materials in their present form can hardly be considered as commercial products, and definite values either for fertilizing or for feeding purposes can hardly be given them. The analyses, however, are important as showing the feeding and fertilizing constituents present which would become very valuable if made more available by removal of the excess of water introduced during the process of manufacture.

IMPORTANT FACTS.

1. No cassava grown in Florida possesses any poisonous character.

2. The crop is perfectly adapted to all parts of Florida, and, in general, to the hard pine lands of the Gulf States.

3. It thrives best on moderately fertile, light sandy-loam soils, on which it withstands drought better than any other staple crop.

4. It produces most abundantly with only moderate applications of fertilizer, the application per acre producing the best results on the Station farm containing 62½ lbs. of acid phosphate, 150 lbs. of cotton seed meal and 37½ lbs. of muriate of potash, having approximately a percentage composition of 2.6 per cent. of phosphoric acid, 3 per cent. of nitrogen and 5 per cent. of potash.

5. There seems to be no advantage in divided applications of this fertilizer, the crop being able to utilize it all without waste from one application.

6. The planting two pieces of seed cane in each hill is recommended as assuring a good stand, most complaints of failure at securing fatisfactory stands being the result of too little seed or of the use of poor seed.

7. The crop is easily harvested from the soils to which it is best adapted. It may be preserved without injury for some months after harvesting, but is usually more conveniently used directly from the field in which it grew.

8. There is no difficulty in preserving seed-cane when placed in beds, the ground being freshly plowed for the purpose, if the butt ends of the canes all touch the ground

and a good covering of hay, moss or straw is placed next the canes and further covered with a light layer of soil.

9. Cassava contains a larger amount of carbo-hydrat food constituents, or fat forming material, than is found in any other staple crop.

10. To secure the best results from its feeding, additions of small quantities of cotton seed meal, cow-peas or velvet beans, whereby the proportion of protein is increased, are recommended.

11. In feeding pigs, meat may be produced from cassava at a cost of about 1 cent per pound. The average cost, under identical conditions with other feed-stuffs, is more than 3 cents per pound.

12. Cassava proves itself a most superior beef fattening food. The cost of live weight beef produced by feeding cassava is 1.1 cents per pound, and in seventy-five days a profit of 59.10 per cent. was made by fattening beef upon cassava.

13. As a raw material for the manufacture of starch, six tons of cassava produces 2,400 pounds of commercial starch, as against 1,200 pounds obtainable from forty bushels of corn.

14. Cassava is a palatable and nutritious human food, capable of being utilized in many ways, and furnishing a most desirable domestic substitute for many imported araticles.

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BULLETIN 50. MAY, 1899.

Florida Agricultural Experiment Station

Pineapple Fertilizers.

By P. H. ROLFS.

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SUMMARY.

1. Comparative tests of fertilizers on pineapples have not been heretofore reported.
2. The pineapple fields on the spruce pine land afford an ideal soil for testing the effects of fertilizers.
3. The results thus far obtained are decisive so that no close discriminations were required.
4. The experiments have been in progress for eighteen months with more than gratifying results.
5. The experiments should be continued for at least five years and also duplicated.
6. The experiments indicate that the fertilizers used to supply ammonia stand in the following order, beginning with the best: (1) blood and bone, (2) nitrate of soda, (3) cotton seed meal, (4) sulphate of ammonia.
7. The potashes stand in the following order: (1) potassium-magnesium carbonate, (2) low grade sulphate of potash, (3) high grade sulphate of potash, (4) muriate of potash, (5) kainit.
8. Bone meal is very much better than acid phosphate.
9. The normal formula in this Bulletin is an arbitrary basis upon which to begin work. The experiments indicate that the following formula is nearer correct for new spruce pine land and probably for all lands—ammonia 4 per cent., potash 6 per cent. and phosphoric acid 1 per cent.
10. There is a certain amount of ammonia, of potash and of phosphoric acid which if applied to the soil proves of greatest benefit to the plants; any variation, either a decrease or an increase of any one or more of these fertilizers will be disadvantageous.
11. The amount of ammonia, of potash and of phosphoric acid which may be applied to the soil to produce the best re-

sults varies with the different sources from which it is obtained.

12. There is a certain amount of ammonia, of potash and of phosphoric acid which produces the greatest freeze-resistance in pineapple plants; any increase or decrease of any one or more of the ingredients produce a less freeze-resistant plant.
13. Freeze-resistance varies with the sources from which the ammonia and potash is obtained.
14. *Caution.* Any one using a fertilizer that is satisfactory should give the new fertilizer a year's trial on a small area of typical soil.

PINEAPPLE FERTILIZERS.

INTRODUCTION.

The pineapple plant is a native of Tropical America. Consequently the history of its cultivation does not date back of 1492. While this fruit has been considered a luxury from the first, its cultivation on a large scale has been somewhat tardy. During the earlier times after its discovery, it was grown as a hot house plant in various European countries, but only to a limited extent, the cost of its production being so great that only the favored few were able to propagate it.

In the West Indies it has been grown on a commercial scale for many years, thriving there without special protection or cultivation. From these islands the plants were gradually disseminated to the Keys of Florida and finally to the main land. The increase in production on the Florida coast has been somewhat slow until quite recently. According to Prof. Webber* the total number of pines raised in Florida during the year 1894 was about 3,000,000 fruits, or 56,209 whole barrel crates. In 1895 there were 22,835 whole barrel crates shipped from Florida. Since then the crop has been increasing rapidly again, but this year it has again been severely reduced by the freeze of last February.

The area of the State in which pineapples are being grown is also rapidly extending. Formerly it was thought that only the East Coast was adapted to the raising of pines. Later they were introduced into the Avon Park and Fort Myers section. Now they are being planted more or less extensively at Orlando, the

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*Report Florida State Horticultural Society, 1896, page 93.

St. Petersburg Peninsula, along the Manatee, at Citra, and at DeLand.

In the more northern localities they are carefully protected from frosts by sheds* and fires. The most rapid increase in acreage has been along the East Coast on the Indian river, and it is probable that this will continue to be pre-eminently the pineapple section of Florida. The rapid transportation facilities afforded by the East Coast Railway have had a stimulating effect upon the increase of acreage of this fruit in that section.

In the body of this bulletin the details of the experiments have been reported as fully as seemed practicable. This is done for the benefit of the pineapple growers who, as a whole, are thoroughly interested in this work, and will necessarily find much information in these details that could not be brought out clearly in general statements.

All details that seemed confusing have been placed nearest to the part to which they relate so they need not be considered until the facts contained in them are needed for a clear understanding. A considerable amount of field notes have been abridged but it is hoped that this abridgement has in no wise made the text matter less clear or definite. That there is much which is not entirely clear to those not engaged actively in pineapple growing is evident, but it is hoped that those who are actively engaged in growing pines will find no difficulty in understanding the thoughts intended to be conveyed. With it all, there are many important questions that occur to those who think on this subject that neither science nor practice is able to answer.

The complete report of the work also assures the pineapple growers that the conclusions must not be accepted as dogmatic truths. Before the whole work can be considered as finished the experiments will have to be tried repeatedly and under varying conditions. Unfortunately the cost of carrying on complete experiments was heavier than the Experiment Station could undertake. Consequently only about one-third of the work has been undertaken, but this has been sufficiently complete that valuable deductions can be made from it.

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*Fla. Exp. Sta. Bul. 37, p. 397.

ACKNOWLEDGEMENTS.

In this connection I wish to offer my sincere thanks to Messrs Ballentine and Moore, who generously put two acres of pineapples at my disposal. I also extend my hearty thanks here for the constant and ready support given us by the East Coast Railway Company, particularly to Col. J. E. Ingraham, who has been active in furthering the work of these experiments.

SOILS.

From a geological standpoint Florida is of very recent origin, especially is it true of that portion south and east of a line drawn from Jacksonville to Tampa. We are told that at one time all of this portion of Florida was part of the great sea bottom, not very deep, and that coral reefs formed along the shore. As these gradually accumulated material, soil was built up by Mangrove trees and other vegetables arresting the sand which was finally blown higher by wind, forming sand dunes. Later another reef would form outward in the sea repeating the process cited above. Finally we have as the latest one formed the island outside of the Indian river, thus making the land to the west of the Indian river and east of the Glades of comparatively very recent origin. Careful examination of the soil shows that the whole section along the East Coast is decidedly of marine origin.

ORIGIN OF SOILS ANALYZED.

The following table of chemical analysis* of Brevard county soil indicates very clearly that it is deficient in all of the essential elements of plant food. By comparing this further with other soils in various parts of Florida, it will be noticed that it con-

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*A. A. Persons, Bulletin 43, Florida Agricultural Experiment Station, pg. 664.

CHEMICAL ANALSIS OF PINEAPPLE SOIL; BREVARD COUNTY.

TYPE OF SOIL	"Field"	Patches	"Saw Palmetto Scrub"		"Yellow Soil"		"White Soil"		General Sub-Soil	Orange Soil
Station Number	Soil 12	Soil 13	Soil 21	Sub-Soil 22	Soil 38	Sub-Soil 39	Soil 40	Sub-Soil 41	Sub-Soil 37	X
Coarse Earth	21. 00	24. 90	3. 20	4 00	11. 40	7. 90	12.20	5.20	11.70	.. ....
Fine Earth	70 00	75. 10	96. 80	96. 00	88. 60	92. 10	87. 80	94.80	88.30	....
Humus	. 24	. 21	. 71	. 07	. 18	. 02	. 16	.01	.12	....
Nitrogen	. 0378	. 0252	. 0742	. 0126	. 0182	. 000	. 0042	.000	.000	.0261
Moisture at 100° C	. 4000	. 2940	. 4880	. 3140	. 1820	. 1000	. 0400	.0080	.0925	.2100
FINE EARTH										
Insoluble Residue	97. 5085	98. 2100	92. 3635	82. 8206	97. 2875	97. 8545	98. 6490	99..4480	98.2240	98.1951
Potash (K^2O)	. 0086	. 0111	. 0612	. 0564	trace	. 0077	. 0034	.0048	trace	.0198
Soda (Na^2O)	. 0510	. 1285	1911	2150	. 0516	. 0492	. 0714	.0344	.0781	.0120
Lime (CaO)	. 2100	. 1075	2. 2325	7. 5250	. 0400	. 0000	. 0000	.0000	.0000	.1150
Magnesia (MgO)	. 0225	. 0099	. 0207	trace	. 0090	. 0990	. 0634	.0036	.0243	.0197
Ferric Oxid (Fe^2O_3)	. 2345	. 1312	. 6156	. 3375	. 8784	. 8602	. 1472	.3180	.7750	.4360
Alumina (Al_2O_3)	. 1169	. 0596				. 4011	. 1328	.0935	.3688	.2440
Phosphorus pentoxid (P_2O_5)	. 0336	. 0192	. 0544	. 0672	. 0416	. 0637	trace	.0160	.0112	.0333
Chlorin	trace	trace	. 0086	trace	trace	trace	trace	trace	trace	trace
Sulphur Trioxid (SO^3)	. 0145	. 0103	trace	trace	trace	.0060	trace	trace	trace	.0530
Carbon Dioxid (CO^2)	. 0000	. 0000	1 6060	5. 4280	. 0000	. 0000	. 0000	.0000	.0000	.0000
Water and Organic Matter	1 7999	1. 3127	2. 8464	3, 5500	1 8600	. 6400	. 7860	.1600	.6250	.8010
Total	100. 0000	100. 0000	100. 0000	100. 0000	100 1681	99. 9840	99 8532	100.0783	100.1064	99.9550

tains much coarse earth (sand), and that it is especially low in humus and nitrogen, and as noted above, it is also wanting in potash and phosphoric acid. Samples numbers 12 and 13 were selected by Mr. S. T. Carrow of Sewell's Point. Numbers 21 and 22 were selected by Mr. L. B. Dowson of Narrows.

HILIGARD'S AVERAGE OF SOILS AND PINEAPPLE SOIL COMPARED.

Prof. Hiligard states that soils containing less than one-tenth of one per cent. of either lime, potash or phosphoric acid may be regarded as being deficient in that particular substance, or substances. Appended is a table giving that average chemical composition of 466 soils taken from the humid portion of the United States.* Applying this standard to our Florida pineapple soils, we would find them exceedingly deficient in the essential constituents for plant growth.

	Hilgard's average of Soils.	FLORIDA PINEAPPLE SOSLS.*		
		Soils	Sub Soils.	Mean of all
	Per ct.	Per ct.	Per ct.	Per ct.
Potash	0.216	.0168	.0230	.0199
Lime	.108	.5180	2.5083	1.5131
Phosphoric acid	.113	.0298	.0489	.0393
Magnesia	.225	.0251	.0342	.0296
Nitrogen		.0319	.0042	.0181

MECHANICAL ANALYSIS OF SOILS AND SUBSOILS.**

Any person having travelled over the section of Florida in which pineapples are grown will have been struck by the course texture white color of the soil. While no very large pieces of gravel are found within it there are still some decidedly coarse grains. Appended is a table giving a physical average of analyses of a number of samples of the West Palm Beach pineapple soil from the Bulletin No. 13, A Preliminary Report on the Soils of Florida, by Prof. Milton Whitney, Chief of the Division of Soils, U. S. D. A.

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*Compiled from table on pg. 664, Bulletin 42, Fla. Agrl. Ex. Sta.

** Milton Whitney, U. S. D. A., Division of Soils, Bulletin 13, page 20.

MECHANICAL ANALYSIS OF SOILS AND SUBSOILS.*

	WEST PALM BEACH "Pineapple Land"		ROCKLEDGE "Spruce-Pine Scrub"	
	Soil 0.-6- depth of	S. Soil 6-36 in. depth of	Soil 0.-6 in. depth of	S. Soil 6-36 in. depth of
Moisture in air, dried sample	15	.07	.15	0.25
Organic matter	1.21	.31	1.06	0.45
Gravel (2-1 mm)	.23	.06	.65	0.66
Coarse sand (1-0.5 mm)	3.02	3.08	12.36	9.07
Medium sand (0.5-0.25 mm)	61.11	57.50	41.42	32.58
Fine sand (0.25-1 mm)	33.76	37.78	41.18	52.13
Very fine sand (0.1-0.05 mm)	.54	.59	2.40	3.26
Silt (0.05-0.1 mm)	.22	.07	.16	0.23
Fine silt (0.01-0.005 mm)	.06	.13	.06	0.18
Clay (0.005-0.0001 mm)	.50	.52	.35	0.51

By comparing the table of the chemical analysis of the soil and subsoil the eye is at once struck by the smallness of the amount of moisture present in air dried sample of the soil. Also with the low organic contents. Just how it is that the pineapple plant can thrive in such soil that seems to be exceedingly deficient in all the necessary qualifications of good land has not been explained. It will probably be necessary to institute careful physiological experiments with the plant itself before the matter shall be thoroughly understood.

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*Div. Soils, U. S. D. A. Bul. 13, p. 28. (Averages.)

SPRUCE PINE AN INDEX OF PINEAPPLE SOIL.

While chemical analyses and physical analyses of the soil have given us no sure index by which we may choose soil for pineapple growing we have another means of determining this, which is much less expensive, and at the same time quite reliable. This is by observing the native vegetables upon the piece of land in question. The native spruce pine land with a fairly good sprinkling of hard wood, such as hickory and scrub oaks, can always be relied upon as being land that will produce a good field of pines, other conditions being favorable. This kind of an index is not confined to the pineapple land by any means. The hammock lands of Florida have long been known to be of superior quality for raising oranges and vegetables. First class pine land also gives good results. So that all we have to do is to go to nature and ask her the question, and if we are sufficiently taught we may read the answer. Hundreds of thousands of pineapple plants have been set out upon flat woods lands, also upon low spruce land; while now and then some of these fields succeed 90 per cent. fail.

LOCATING THE EXPERIMENTS.

During the fall of 1897 the Experiment Station decided to undertake some comparative tests of the effects of different fertilizer ingredients upon pineapples. In studying the situation, before going into the field it became very evident that the East Coast of Florida was pre-eminently the section devoted to the growing of pineapples. It was, therefore, thought that this would be the best place to locate the experiments. Inquiries were made as to where the most suitable field could be obtained, the Experiment Station agreeing to plan the experiments, furnish the fertilizer, and superintend its application, and the pineapple grower was to furnish the field in which the experiments were to be conducted. The fruit to belong to the pineapple grower, but the Experiment Station was to have the right to ascertain the quantity and quality of the fruit. The readiness with which the pineapple growers responded to these requests was certainly commendable. In less than a week's time more than a hundred acres of pineapples that were thought to be in proper conditions for experimenting upon were offered to the Experiment Station. After discussing the matter carefully with disinterested people and with those who were thought to be fully familiar with different locations and conditions, it was finally decided to accept the plot offered by Messrs. Balentine and Moore near Jensen.

DESCRIPTION OF THE FIELD.

This field is located at Chetolah station immediately west of the railroad track. The land was formerly covered with spruce pine with a mixture of a few trees of scrub oaks and hickories. It had been cleared of nearly all the stumps and most of the trash removed, much of it being burned on the field. As a whole the field presented a very even appearance, the west end being well upon the hill, the east end near the railroad track. After the clearing the field had been broken up and raked over, no fertilizer being applied before the plants were set. The plants were set out during the summer of 1897 in lands running north and south, varying from 29 to 33 plants deep, and 107 to 118 rows from north to south. The paths between the lands are about four feet wide. The plants are set in checks about 22 inches each way.

The surface of the soil is of the ordinary white sand so common along the East Coast. The hill upon which the field is located rises gradually to the height of probably 30 to 40 feet. In no portion of the experiment plots is the rise abrupt. While the land as a whole, is somewhat more productive at the foot of the hill, there is no abrupt variation, excepting those few small spots which are always apparent in fields. As a whole the location and field must be regarded as being as nearly ideal for experiment work as could be well obtained without selecting the virgin land and preparing it from the beginning with this end in view. More fertile lands could easily have been secured, but these conditions would tend to vitiate the very result at which we were aiming, viz, the effect of certain fertilizers and certain fertilizer combinations upon the plants. The point we were aiming at was so well stated by a visitor to the field that his quotation will bring out the facts exactly. "I didn't come here to see fine pineapples. I can raise those myself, but I came here to see what fertilizer is detrimental to pineapples and what is beneficial to them so I can use the cheapest and receive in return the greatest yield. Then, again, I want to see what is detrimental so I can avoid that. We all know that there are many more bad fertilizers than good ones, and these experiments ought to prove why they are bad."

OBJECT OF THE EXPERIMENTS.

The above short talk expresses the object of the experiment so well that it hardly need be repeated. We must emphasize the fact that under the conditions of the soil employed we should not expect to find a majority of the plots coming out favorably. If 50 per cent. of the experiment plots had given fine growth of the pineapple plants it would have been a very discouraging experiment indeed, from the standpoint of fertilizer tests, as it would have indicated that the cause of much trouble in pineapple fields must be sought in an enntirely different line, but the fact that a few plots have given unusual returns, a few quite favorable returns, a few good returns, a few indifferent, and a large percentage either bad or very bad, indicates very clearly that this is an unusually profitable field for investigation. The experiments being located on soil that is practically devoid of plant food, there was no other source from which the pineapples could derive their nourishment. Had productive land been accepted, many of the plots that are now classed as 5th and 6th rate would have gone into higher classes, some doubtless to the 1st class, thus defeating the very result sought.

We must dismiss from our minds all ideas of having an ideal pineapple field when we are seeking facts in regard to the effects of fertilizer. To produce a perfect field is the object of every pineapple grower, and the Experiment Station wishes to ascertain WHY he fails.

FERTILIZERS.

One of the most difficult problems in connection with modern horticulture is to ascertain just what commercial fertilizer can be applied to best advantage to any particular crop. The whole subject is of such recent origin that we have not yet had time to settle this matter very definitely. A typical pineapple field under ordinary conditions in Florida is pre-eminently an ideal place for experimenting with these substances. From the foregoing discussion of the chemical analyses of the soil the thoughtful reader will have discovered that we have here an almost insoluble medium in which the plants rest. Any addition to the soil must, therefore, react directly upon the pineapple plants. The whole field is nearly in such condition as the scientific workers desire to have for studying the effects of plant food. The experimenter thus having almost insoluble medium in which to grow plants may add the commercial fertilizers in such quantities and combinations as he desires. The pineapple soil being practically insoluble the disturbing agent, if any exists, must be contained in the fertilizer. Thus having such ideal conditions the work of these experiments was begun with enthusiasm that was only surpassed by that experience as the work progressed.

OPINIONS OF FERTILIZERS.

There is probably no greater diversity of opinion on any subject than in regard to the kind of commercial fertilizer to be used. Every pineapple grower seems to have a favorite fertilizer house and a favorite brand of fertilizers. By turning to the reports of the State Chemists from various portions of the United States one is astonished by the number of different brands of fertilizers that are placed on the market. The number in the United States as a whole would reach up into the thousands. It will, therefore, be seen that it would be a hopeless task to experiment with any private brand, as it likewise would be of no value. A fertilizer house of good standing among the vegetable growers of Florida during the winter of '97 and '98 used sulphate of ammonia as a main source of its nitrogen. This same house selling the fertilizer under the same name and for practically the same price six months later used nitrate of soda as the main source of nitrogen. Of course there was nothing wrong in the change from sulphate of ammonia to nitrate of soda, as the fertilizer house had not agreed to use either one or the other as a source of nitrogen, and it was to the interest of the firm to use whatever material was the cheapest. So far as we know the vegetable growers were served as well in one case as in another, but if this same change should be made in pineapple fertilizer the matter would be quite different. It, therefore, becomes imperative for pineapple growers to know not only what the analysis of their fertilizer is, but also just what the source of each fertilizer ingredient is.

Before beginning the experiments upon pineapples diligent inquiry was made among as many pineapple growers as could be interviewed, and notes taken upon their advice and recommendations in regard to fertilizers. A compilation of their opinions was found to give very contradictory information. Some general points were conceded by a considerable majority. The most striking of these is that a mixture of cotton seed meal and tobacco dust are useful for placing in the bud of young plants to keep them from "sanding," and to destroy the red spider. Another opinion that acid phosphate is not a good substance to use in connection with pineapples seems to be quite general.

A considerable number of prominent growers advocate the use of cotton seed meal as a source of nitrogen. Nitrate of soda does not seem to stand well; still it has advocates and admirers. Sulphate of ammonia comes in for a generous share of commendation. The use of blood and bone is advised by a number of prominent growers. Bone meal has very few admirers.

As a source of potash, high grade sulphate of potash seems to be the greatest favorite. Low grade sulphate of potash has some strong advocates. Kainit is condemned by most of the growers. Muriate of potash has but few admirers. There are only a very few people who advocate the use of no potash at all.

To enumerate the private brands that receive commendation would almost be equal to enumerating all that are being sold.

On the other hand to enumerate those private brands which are condemned by some pineapple growers would likewise be equal to enumerating all the private brands sold. Some of this trouble is doubtless the fault of the grower and some of the trouble must be the fault of the fertilizer houses. The fact cited before that certain fertilizer houses change the ingredients used in their fertilizer without giving the information to their purchaser makes a certain brand good at one time and bad at another. Of course there is no implied or stated agreement that the house shall use any one form of nitrogen or any particular kind of potash. As a rule their statements in regard to the composition of their fertilizers are so general that nearly any substance may be used as a source of ammonia, and most of the forms of potash may be interchanged and possibly exclude acid phosphate.

The compilation of opinions from various pineapple growers mentioned above gave authority for condeming any form of ammonia that was offered for sale on the market. Also any form of potash that was being sold. Under these conditions the diligent inquirer after opinions found himself decidedly at sea. On the other hand as stated above it is not difficult to find people of more than local standing to advocate the use of any form of commercial fertilizers that were on the market. Undoubtedly most of the opinions are founded upon experience, costing the grower a considerable amount of money.

DISCUSSION OF FERTILIZERS USED.

AMMONIA.

COTTON SEED MEAL.

This substance is so common to our market, and has been of such general use that every one seems to know what it is. Not many years have passed since this product was regarded as a waste and in the way. Sometimes the substance is added to the soil in the form of whole seeds; that is, the whole cotton seed without having the oil expressed. This, however, is a waste of labor and material inasmuch as the oil it contains is of little or no value as a fertilizer, and makes up a very considerable portion of the weight of the cotton seed. After the oil has been expressed the remaining material is ground up in fine flour known on the market as cotton seed meal. The price of cotton seed meal is quite constant, bright cotton seed meal being slightly higher priced than the dark. The difference in prices represents accurately the difference in value as a fertilizer.

As a source of nitrogen for pineapples we would not consider it as of first class value, especially for spruce pine land. Low spruce pine land, long leaf pine land, and the close compact soils generally give fair returns for the cotton seed meal used as a source of ammonia. As a first application to keep plants from being "sanded" (see appendix) it is of decided value, but for later applications it stands rather low in the the list of those fertilizers which are sources of ammonia. Some very excellent fields of pineapples have been produced with nothing else than cotton seed meal, but this can not be continued indefinitely. The pineapple grower, who finds cotton seed meal a source of ammonia for his particular piece of land, should not change the source, except as an experiment, until he is convinced that there is a better form. Besides being a source of ammonia, cotton seed meal contains a small quantity of potash and phosphoric acid, but these quantitiies are really too small to be taken into consideration when we are fertilizing on typical pineapple land.

DRIED BLOOD.

This, too, was formerly a refuse and one which created more or less disturbance at packing houses. Chemical investigation showed that blood was rich in ammonia, and consequently the dried product would give a fertilizer of great value. It contains about twice as much ammonia as cotton seed meal, being thus a concentrated form, and sells for about twice the price. To the pineapple grower this is quite an item, especially in view of the fact that all of the fertilizer has to be applied by hand.

BLOOD AND BONE.

This substance was formerly produced from refuse meat, bone and blood of the packing houses collected in vats, dried and ground, making more or less a finely divided stinking substance. This has met with so much favor tnat the price has gone up to a considerable more than the real value as a fertilizer for ordinary crops.

BLOOD AND BONE AND TANKAGE.

Tankage is the contents of the stomach and intestines of slaughtered animals. This material is collected in vats, dried and pulverized. Its value as a fertilizer is small. In more recent years the packing houses have mixed with the tankage a certain amount of dried blood and ground bone. This has been placed upon the market as blood and bone, giving us an odorless, or nearly so, blood and bone. It was this variety of the blood and bone that was used upon the experiment plots.

NITRATE OF SODA.

This substance is known by various names in various portions of the world. The term nitrate of soda, however, is so generally applied to it in this country that the others need not be considered. This is mined in Chili from natural deposits in several places of that country. It is useful mainly as a source of ammonia; one that is quickly available, especially to the pineapple plant. Experiments in connection with the use of nitrate of soda as a source of ammonia indicate that it must be used with some precaution. It has a strong affinity for water, and may destroy plants that we seek to fertilize if applied in large doses. In using this substance for pineapples or any other plant we should apply a little at a time, and apply it frequently. In the experiments this was not done, because of a desire to keep the work as uniform as possible, and to keep it in the line with the work that was usually being carried out by the pineapple growers.

Fertilizer houses usually employ this as a source of quickly available ammonia, using cotton seed meal or dried blood as a form to be more slowly available. This seems to give an ideal way of preparing the fertilizer, but it must be done with some reservation, as more recent experiments indicate that a very considerable portion of the ammonia may be changed to a form not available when several of these compounds are mixed. Usually nitrate of soda is the cheapest form of ammonia.

SULPHATE OF AMMONIA.

Great quantities of sulphate of ammonia are manufactured in England, from where we receive the greatest amount of this material. In the burning of coke in the coal districts a gas rich in nitrogen is given off. This is arrested in retorts and deposited as ammonium sulphate, or sulphate of ammonia, as it is called on the market. This is the most concentrated form of ammonia which we have for fertilizing purposes, containing nearly 25 per cent. For many plants it has a decided advantage over nitrate of soda, but for the pineapple plant on high spruce land we must consider it as of low fertilizing value. This is somewhat of a surprise, especially in view of the fact that it has proven itself so valuable in connection with other fruits.

POTASH.

METHODS OF PREPAPING HIGH-GRADE POTASH SALTS.*

"The potassium chloride [muriate of potash] is prepared by leaching the carnallite or other crude salts containing potassium chloride, either with hot water, or a hot concentrated solution of magnesium chloride in such proportions as to dissolve the potassium and magnesium chlorides but not the common salt. On cooling this solution to 70 deg. C. and and allowing it to remain for some time, the potassium chloride is deposited in a crystalline form. A second crop of crystals is also obtained by cooling the mixture to usual temperatures. On concentrating the residual mother liquor, another crystalline deposit, consisting of mixed potassium and magnesium chlorides, is obtained, which can be added to the crude salt and re-treated as above. The crystals of potassium chloride obtained by the first two crystallizations are washed, drained, dried, and packed for shipment. By repeated evaporations, crystallizations and resolution, about 85 per cent. of the potassium chloride is finally obtained, only about 15 per cent. being lost in the waste waters. Even those waters are evaporated and sold for fertilizing purposes to nearby-farmers.

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*Wiley, Dr. H. W., Yearbook, U. S. D. A., 1896, p. 119.

"Potassium sulphate is most easily prepared by treating the chlorine compounds of potash, obtained as already described, with sulphuric acid. Free hydrochloric acid is generated by this treatment, which may be collected in cold water in the usual way.

"The double sulphate of potash and magnesia is made for commercial purposes from the impure kainite as it comes from the mines. A saturated solution of the crude kainite, made with water under pressure at a temperature of 250 deg, C., will deposit the double sulphate in fine crystals on cooling.

"Potassium carbonate is made from the chloride [muriate] or sulphate by roasting the salts with finely divided charcoal and carbonate of lime. By this process potassium carbonate is formed, which can be extracted by lixiviation. For fertilizing purposes this salt is used chiefly for tobacco."

KAINIT.

This is a mineral salt composed of potassium sulphate, magnesium sulphate, magnesium chloride, and a small amount of potassium chloride. These salts are mixed in various proportions. It was thought that this was deposited from sea water. The largest mines are located at Stassfurt, Germany. These are being worked extensively and produce the kainit brought to the United States. As the composition of this salt varies considerably so the color of it varies somewhat from a dirty gray to a yellowish-red mass.

For some crops it can not be used profitably as a fertilizer, because of the amount of chlorine contained within it. Other crops, however, are benefited by an application of this potassium salt. Pineapples are injured by its application, probably not because of the presence of chlorine in the composition, but it may be for some other reason. At the present time we simply know that the substance is injurious.

SULPHATE OF POTASH, LOW GRADE.

This is also known on the market by the name of double potash salts, being a sulphate of potash and of magnesia. Its origin is from kainit. By washing and several forms of treatment double salts, sulphate of potash and sulphate of magnesia, are secured. This substance on our market ranges usually from 22 to 26 per cent. of potash, or what is frequently labelled 44 to 50 per cent. sulphate of potash. This simply means that the total amount of sulphate of potash is 44 to 50 per cent., while the amount of actual potash is only from 22 to 26 per cent.

The sulphate of magnesia in this mixture is thought to be of special value in connection with certain crops. It seems to be of some importance in connection with fertilizing of pineapples, as is indicated by the experiments.

SULPHATE OF POTASH, HIGH GRADE.

This potash salt is a still more refined product than the sulphate of potash, low grade, being the most refined product in the process of refining sulphate of potash salts, double salts, or low grade sulphate of potash, containing the residual impurities. Sulphate of potash, high grade, frequently contains as much as 98 per cent. sulphate of potash or an equivalent of 53 per cent. of actual potash, though as a rule the amount of potash is somewhat lower than this, and for practical purposes we would find about 50 per cent. the right figure to consider. For many plants this grade of potash is very superior. For pineapple it stands among the good potash salts, but is somewhat lower in the scale than low grade sulphate of potash.

MURIATE OF POTASH.

As was stated before kainit is the direct product of nature occuring in that form in the earth. This substance is mined and washed, and further treated when finally the muriate of potash results as a product. While most of the muriate of potash, which is found on our market contains about 50 per cent. of actual potash, there are some forms of muriate of potash that are slightly higher, but for practical purposes we may regard them as containing about 50 per cent. of actual potash. Frequently labels state that the substance is 95 to 98 per cent. pure. This does not mean that it contains 95 to 98 per cent. potash, which would be a physical impossibility, but simply means that it contains 95 to 98 per cent. of muriate of potash.

For many crops muriate of potash is the cheapest form of potash fertilizers. If the pineapples are to be used at home or sold in local markets we will probably find muriate of potash a little better than the sulphate of potash, from the fact that it adds very considerably to the sweetness of the pineapple. On the other hand it makes a very tender apple, and one that is very liable to "plug," and does not ship very well.

POTASSIUM-MAGNESIUM CARBONATE.

This form of potash has also its origin in kainit. It contains about 18 per cent. of actual potash. It has not been offered to the southern trade so we can not say just what the prices would be, but we are assured that the price per unit of the actual potash will be the same as that in other potash salts. This salt being a carbonate it is in the same form as the potash present in ashes. They have been considered a favorite source of potash for pineapples, and it was for this reason that the carbonate of potash was used in the experiments. By referring to the photographs and tables it will be seen that this form of potash has thus far proved itself superior to any other form. It should, however, be used for a number of years, say five or ten, before it can be recommended without reservation. The present indications are, however, that not only will the plants be fairly productive, but that the fruit will be of good size and have good shipping qualities together with excellent flavor.

EFFECTS OF DIFFERENT KINDS OF POTASH.

A number of people have expressed their surprise that the different forms of potash should cause such a variation in the size of the plants and quality of fruit, but when we consider the matter from a chemical standpoint, we are really more surprised that these substances which are so radically different and similar only in one respect, in that they contain potash as one of the elements, should give results so nearly alike. In the case of kainit we have a sulphate of potash mainly to do with, but beside this we have a large quantity of sodium chloride (table salt) magnesium sulphate, magnesium chloride and various other materials. All of these are brought into the soil, some of them in quantities equal to that of the fertilizer constituent. In the case of sulphate of potash, low grade, we have fewer foreign substances introduced. In the case of sulphate of potash, high grade, we have almost a pure substance composed of two atoms of potassium, one atom of sulphur, and four atoms of oxygen. These substances must be decomposed before the potash can be made useful to the plant. In the case of muriate of potash the substance is quite pure, but this is radically different, because it is made up of one atom of potassium and one atom of chlorine. Before the potash can be utilized in building the plant tissue, the chlorine has to be separated from the potassium. In the case of potassium-magnesium carbonate the substance is quite impure, containing considerable material beside that which is actually wanted by the plant, it being made up most largely of potassium, carbon, oxygen and magnesia. Before the potassium can be utilized by the plant it must be separated from the carbon and oxygen.

From the foregoing discussion it will be seen that it is really surprising that the plant can separate the desirable elements from those that are not essential, especially when so many of them are introduced with the essential element, potassium.

The same line of discussion might be taken up in the case of the substances which give us ammonia, but this whole question would really require a volume by itself, and after all that we know about it should have been written we would find that we were merely beginning to learn something about it.

PHOSPHORIC ACID.

The supply of phosphoric acid has been from two sources. First that of bone meal, and second that of acid phosphate or dissolved rock. A good deal has been said about the presence of free sulphuric acid in acid phosphate and also about it in dissolved bone. The following quotations from authorities on this subject are, therefore, in place:

NO SULPHURIC ACID IN ACID PHOSPHATE.*

"In practice it is usual to take less than the theoretical quantity of sulphuric acid, so as to be sure that there be left over in the superphosphate mixture, no free unconsumed acid which would be injurious to vegetation.

"WELL MADE SUPERPHOSPHATES CONTAIN NO FREE ACID.**

"In the earlier history of the use of acid phosphates, or rock superphosphates, objections were urged against them, and are to some extent at the present time, because of the supposed deleterious effects of the acids contained in them, and these objections were undoubtedly encouraged—certainly not discouraged—by those manufacturers who used only genuine bone superphosphates. While the objections on this ground may have had some basis in earlier times, before their manufacture was well understood, there can be no rational objection to their use at the present time, when they are properly made; for while in fresh superphosphates a portion of the phosphoric acid may be in the form of 'fresh' phosphoric acid, this form in ordinary superphosphates is practically all combined with lime or other minerals before it is placed upon the market, and there is really no more 'free' acid in the rock superphosphate than in any other. It is quite likely this erroneous impression arose from the fact that strong sulphuric acid was used in the manufacture, and the belief existed that it remained as such. No free sulphuric acid exists in well made superphosphates. The sulphuric acid is combined with the lime to form gypsum, as already described, and the free phosphoric acid combines with the lime to form either a soluble or a reverted form."

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*Pickell, Dr. J. M., Fla. Exp. Sta. Bulletin 10, page 15.

**Voorhees, E. B., Fertilizers, p. 89 (see appendix.)

BONE MEAL.

In making the application of bone meal it was considered that there would be 4 per cent. of available phosphoric acid, and the amount applied was guaged accordingly. The origin of the bone meal is probably familiar to every pineapple grower. Bones in various degrees of decomposition from those of the animals just slaughtered to bones that have been bleaching in the sun for a considerable time are placed in mills and ground. This material is then put upon the market as bone meal. It is reduced to various degrees of fineness. Sometimes the finer forms are known as bone flour, bone dust, etc. Some of the coarser forms are sometimes spoken cf as ground bone or broken bone. The more finely divided the bone the better it is for the use of fertilizer. The fine particles being incorporated into the soil and the roots coming in contact with these the process of absorption begins.

Bone meal has been used for fertilizer for many years. In the European countries no bones are allowed to go to waste or be destroyed, but they are carefully gathered and either broken into pieces or ground and then applied as fertilizer. In America the industry has been limited to within the last decade or two. It has not been many years since the great number of buffalo bones wasting on the prairies have been collected and utilized.

It has been difficult to establish what portion of bone phosphate in ground bones is really available to plants. Recently some chemists in Germany have been investigating this matter and declare that bone phosphate is not available as plant food, substantiating their position by a great number of experiments continued through many years. Later come equally positive statements that seem to be founded on good evidence that a certain amount of the bone phosphate is available to certain plants. We are not in a position, therefore, at the present time to say definitely that the value of bone meal exceeds that of the ammonia contained in it, or say about $12 per ton. The experiments reported in this bulletin have not been continued a sufficient length of time to allow any definite conclusion on this to be drawn. After the work shall have been continued for a period of five or ten years on the same plots, the phosphoric acid originally in the soil would doubtless be entirely exhausted, and some interesting conclusions may be possible. At the present time, however, the indications are that bone meal for some reason or other has a value as a fertilizer beyond that expressed in the nitrogen it contains. That is, those plots fertilized with bone meal show decided advantage over those being fertilized with otherwise identical material, but wanting bone meal. In this connection it is interesting to note that the position held by those who regard the phosphorc acid in bone as not available to plants, is based principally upon the work by Professors Maercker and Steffek, of the Halle Exp. Station, Germany. In New Jersey Exp. Sta. Report for 1895, pages 93-99, we find some interesting discussion in this line. The authors make the following pertinent statement: These studies indicate, first, that on the average more than one-fourth of the phosphoric acid in bone is in an available form; as a rule the finer and softer the bone the greater the degree of availability.

Even after it has been definitely settled that bone phosphate contains no phosphoric acid available to the plants originally experimented with in pot cultures, such as were used in Germany under the artificial conditions, it will still remain a question to be solved as to whether the phosphoric acid is not available to the pineapple plants under the conditions of our fields. The fact that pineapple plants will flourish in soil which from a chemical standpoint is deficient in all the elements which go to make up a fertile soil and in a soil that is radically different from other fertile soils in physical constitution throws us into an entirely new field of investigation.

We have here a plant which increases in size and weight during the season of greatest drought, when there may be no rains for six, eight, and at times ten weeks, in a soil containing "99.44 per cent. of insoluble residue!"

During the dry season dews are usually heavy, giving the plant considerable moisture, which is conducted to the root system by its peculiarly shaped leaves. Dew formed on living plants has been shown to contain a very considerable amount of carbonic acid in solution. This water which contains carbonic acid in solution is a much better solvent of tri-calcium phosphate than pure water. Is it not possible that we have here a partial explanation of the strange fact that this plant may flourish in a soil so nearly sterile?

ACID PHOSPHATE.

The pineapple growers of Florida are so familiar with the origin and treatment of phosphate rock to produce a common acid phosphate for our market that a repetition of that would seem almost useless.

The phosphate rock is taken from the earth either mined or dredged from beneath water in creeks and rivers. It is then washed to free it from dirt. The rocks are then subjected to a grinding process, thus being reduced to small size, afterwards to the condition of flour. In this state it is treated with sulphuric acid to make acid phosphate, superphosphate or what may be called available phosphoric acid. The substance usually found on the market contains from 6 per cent. to 14 per cent. of available phosphoric acid. This substance has been used for a number of years as a source of phosphoric acid in fertilizers, but pineapple growers have gradually discarded its use in connection with pineapple fertilizers. In connection with vegetables and fruit trees its value can hardly be denied.

Many of the pineapple growers believe that acid phosphate was detrimental to pineapples on account of free sulphuric acid being used to make the phosphate available. This conclusion is not borne out by the result of the experiments. In those plots which were supplied with phosphoric acid from acid phosphate, we find almost without exception, in sections where the greatest quantity was supplied it is slightly different (sometimes better, sometimes poorer) than where the least quantites had been used. If the difference had been due to the presence of the sulphuric acid in the material the section which received 100 per cent. more of acid phosphate would have been decidedly inferior to those in which only one-half of the amount had been used.

ANALYSIS OF FERTILIZERS USED.

	Ammonia	Potash	Available Phos. Acid	Reverted Phos. Acid	Total Phos. Acid	Lime	Magnesia	Sulphuric Acid	Cholorine
Cotton seed meal	8	1			3				
Sulphate of ammonia	25							60	
Nitrate of soda	19								
Blood and bone	10		?	?	?				
Kainit		12				1	10	20	33
Sulphate of potash low grade		22				3		44	3
Sulphate of potash high grade		48						46	
Muriate of potash		50							48
Pot-magnesia, corbonate		18				?	16		
Bone Meal	5		1	7	23				
Acid phosphate			14	3	15	*45			

FORMULA USED AS A NORMAL FERTILIZER.

As a starting point upon which to base the applications of fertilizers the following formula was used:

Nitrogen	3 per cent.
Potash	7 per cent.
Available phosphoric acid	5 per cent.

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*Sulphate of lime.

On February 7 and 8, 1898, an amount of fertilizer that would be equal to about one and one-half tons of the above formula was used. A second application equal to about two and one-half tons per acre was applied June 27 and 28, 1898. A third application equal to about two tons of the above formula was made November 4 to 12, 1898. A fourth application was being planned at the time of the freeze of February 13, 1899. On account of this freeze the application was delayed until April 1, 3 and 4, 1899. At this time an amount equal to about one and one-half tons of the above formula was applied. A fifth application of the same quantity was made July 6, 1899. After the freeze of February 13, 1899, it was thought best to reduce the amount of fertilizer to be applied because the leaf surface of the pineapple plants had been greatly reduced.

The formula used as a basis for these experiments was one suggested by Mr. T. V. Moore. The amount of fertilizer to be used as standard was left to his discretion, and the fertilizer was applied as nearly as practicable at the time he suggested. Mr. Moore having had long and extensive experience in pineapple growing, his suggestions in connection with the experiments were found to be of the greatest value, especially that part which is connected with the practical growing. In short this experiment is a co-operative one in which Mr. Moore gives the Experiment Station the benefit of his practical experience, and the Experiment Station furnished and prepared the fertilizer. For his kindness and suggestions in many ways the Experiment Station is under many obligations, and pineapples growers who find themselves benefitted by this work should likewise feel that Mr. Moore deserves credit and consideration for devotion to their interests.

PLAN OF THE FIELD.

The field under experimentation contains about two acres. All plots treated with incomplete fertilizer (one in which one or two of the three fertilizers, nitrogen, potash or phosphoric acid is wanting) were four rows wide or contained about a one-hundredth acre. All plots fertilized with complete fertilizer (one containing nitrogen, potash and phosphoric acid) contain about one-twentieth acre.

The following table gives the exact number of plants to each plot and the amount and kind of fertilizer applied to each plot for the first application, February 7 and 8, 1898. The basis for determining the amount of each kind of fertilizer is stated on page 30 under the discussion of chemical analysis of a Normal Fertilizer. The chemical analysis of each ingredient is given on page 30 giving a table of analyses of fertilizers used.

FORMULAE FOR

Application 1, applied February 7 and 8, 1898.

LAND I, 33 PLANTS DEEP.

Plot 1—4 rows (rows 1-4) 1-100 acre.
    8 lbs. cotton seed meal.
Plot 2—4 rows (rows 4-8) 1-100 acre.
    8 lbs. cotton seed meal.
    4 lbs. sulphate potash, low grade.
Plot 3—24 rows (rows 8-32) 1-20 acre.
    8 lbs. cotton seed meal.
    20 lbs. sulphate potash, low grade.
    80 lbs. bone meal.
Plot 4—4 rows (rows 32-36) 1-100 acre.
    2 lbs. cotton seed meal.
    16 lbs. bone mea l.
Plot 5—24 rows (rows 36-60) 1-20 acre.
    40 lbs. cotton seed meal.
    20 lbs. sulphate potash, low grade.
    30 lbs. acid phosphate.
Plot 6—4 rows (rows 60-64) 1-100 acre.
    8 lbs. cotton seed meal.
    6 lbs. acid phosphate.
Plot 7—4 rows (rows 64-68) 1-100 acre.
    8 lbs. cotton seed meal.
    2 lbs. muriate potash.
Plot 8—24 rows (rows 68-92) 1-20 acre.
    8 lbs. cotton seed meal.

8 lbs. muriate potash.
80 lbs. bone meal.
15 1-2 rows to uncleared land not fertilized

LAND 2, 33 PLANTS DEEP.

Plot 9—23 rows (rows 1-23) 1-100 acre.
40 lbs. cotton seed meal.
8 lbs. muriate potash.
30 lbs. acid phosphate.
Plot 10—4 rows (rows 23-27) 1-100 acre.
8 lbs. cotton seed meal.
8 lbs. kainit.
Plot 11—24 rows (rows 27-51 1-20 acre.
8 lbs. cotton seed meal.
40 lbs. kainit.
80 lbs. bone meal.
Plot 12—24 rows (rows 51-75) 1-20 acre.
40 lbs. cotton seed meal.
40 lbs. kainit.
30 lbs. acid phosphate.
Plot 13—4 rows (rows 75-79) 1-100 acre.
8 lbs. cotton seed meal.
5 lbs. potassum-magnesium carbonate.
Plot 14—24 rows (rows 70-103) 1-20 acre.
8 lbs. cotton seed meal.
25 lbs. potassium-magnesium carbonate.
80 lbs. bone meal.
5 rows to uncleared land not fertilized.

LAND 3, 33 PLANTS DEEP.

Plot 15—25 rows (rows 1-25) 1-100 acre.
40 lbs. cotton seed meal.
25 lbs. potassium-magnesium carbonate.
30 lbs. acid phosphate.
Plot 16—4 rows (rows 25-29) 1-100 acre.
8 lbs. cotton seed meal.
2 lbs. sulphate potash, high grade.
Plot 17—22 rows (rows 29-51) 1-20 acre.

8 lbs. cotton seed meal.
8 lbs. sulphate potash, high grade.
80 lbs. bone meal.

Plot 18—24 rows (rows 51-75) 1-20 acre.
40 lbs. cotton seed meal.
2 lbs. sulphate potash, high grade.
30 lbs. acid phosphate.

Plot 19—4 rows (rows 75-79) 1-100 acre.
2 lbs. sulphate ammonia.

Plot 20—4 rows (rows 79-83) 1-100 acre.
2 lbs. sulphate ammonia.
8 lbs. sulphate potash, high grade.

Plot 21—24 rows (rows 83-107) 1-20 acre.
2 lbs. sulphate ammonia.
8 lbs. sulphate potash, high grade.
80 lbs. bone meal.

2 and 1-4 rows to uncleared land not fertilized.

LAND 4, 33 PLANTS DEEP.

Plot 22—24 rows (rows 1-24) 1-20 acre.
2 lbs. sulphate of ammonia.
8 lbs. muriate of potash.
80 lbs. bone meal.

Plot 23—24 rows (rows 24-48) 1-20 acre.
10 lbs sulphate of ammonia.
8 lbs. muriate of potash.
30 lbs. acid phosphate.

Plot 24—24 rows (rows 48-72) 1-20 acre.
2 lbs. sulphate of ammonia.
40 lbs. kainit.
80 lbs. bone meal.

Plot 25—24 rows (rows 72-96) 1-20 acre.
10 lbs. sulphate of ammonia.
40 lbs. kainit.
30 lbs. acid phosphate.

15 rows to uncleared land not fertilized.

LAND 5, 33 PLANTS DEEP.

Plot 26—24 rows (rows 1-24) 1-20 acre.
10 lbs. sulphate of ammonia.

25 lbs. potassium-magnesium carbonate.
30 lbs. acid phosphate.
Plot 27—4 rows (rows 24-28) 1-100 acre.
3 lbs. nitrate of soda.
Plot 28—4 rows (rows 28-32) 1-100 acre.
3 lbs. nitrate of soda.
2 lbs. sulphate of potash, high grade.
Plot 29—24 rows (rows 32-56) 1-20 acre.
14 lbs. nitrate of soda.
8 lbs. sulphate of potash, high grade.
30 lbs. acid phosphate.
Plot 30—24 rows (rows 56-80) 1-20 acre.
14 lbs. nitrate of soda.
8 lbs. muriate of potash.
30 lbs. acid phosphate.
Plot 31—24 rows (rows 80-104) 1-20 acre.
14 lbs. nitrate of soda.
20 lbs. sulphate of potash, low grade.
30 lbs. acid phosphate.
7 rows to uncleared land not fertilzed.

LAND 6, 29 PLANTS DEEP.

Plot 32—24 rows (rows 1-24) 1-20 acre.
14 lbs. nitrate of soda.
40 lbs. kainit.
30 lbs. acid phosphate.
Plot 33—24 rows (rows 24-48) 1-20 acre.
14 lbs. nitrate of soda.
25 lbs. potassium-magnesium carbonate.
30 lbs. acid phosphate.
Plot 34—24 rows (rows 48-72) 1-20 acre.
34 lbs. blood and bone.
Plot 35—23 rows (rows 72-95) 1-100 acre.
34 lbs. blood and bone.
8 lbs. sulphate of potash, high grade.
15 rows, 3-4 row and 1-4 row to uncleared land not fertilized.

LAND 7, 29 PLANTS DEEP.

2 short rows not fertilized.
Plot 36—24 rows (rows 1-24) 1-20 acre.
34 lbs. blood and bone.

20 lbs. sulphate of potash, low grade.
Plot 37—24 rows (rows 24-48) 1-20 acre.
34 lbs. blood and bone.
40 lbs. kainit.
Plot 38—24 rows (rows 48-72) 1-20 acre.
34 lbs. blood and bone.
8 lbs. muriate of potash.
Plot 39—24 rows (rows 72-96) 1-20 acre.
34 lbs. blood and bone.
25 lbs. potassium-magnesium carbonate.
18 1-2 rows to uncleared land not fertilized.

LAND 8, 32 PLANTS DEEP.

2 short rows not fertilized.
Plot 40—5 rows (rows 1-5) 1-100 acre.
8 lbs. cotton seed meal.
2 lbs. sulphate of potash, high grade.
6 lbs. acid phosphate.
10 lbs. lime, air slacked.
Plot 41—4 rows (rows 5-9) 1-100 acre.
2 lbs. nitrate of soda.
8 lbs. kainit.
6 lbs. acid phosphate.
10 lbs. lime, air slacked.
Plot 42—4 rows (rows 9-13) 1-100 acre.
2 lbs. sulphate of ammonia.
2 lbs. sulphate of potash ,high grade.
6 lbs. acid phosphate.
10 lbs. lime, air slacked.
Plot 43—4 rows (rows 13-17) 1-100 acre.
7 lbs. blood and bone.
5 lbs. potassium-magnesium carbonate.
6 lbs. acid phosphate.
10 lbs. lime, air slacked.
Plot 44—4 rows (rows 17-21) 1-100 acre.
8 lbs. cotton seed meal.
2 lbs. sulphate of potash, high grade.
6 lbs. acid phosphate.
100 lbs. muck, air dried.
Plot 45—4 rows (rows 21-25) 1-100 acre.
2 lbs. nitrate of soda.
8 lbs. kainit.
6 lbs. acid phosphate.

100 lbs. muck, air dried.
Plot 46—4 rows (rows 25-29) 1-100 acre.
2 lbs. sulphate of ammonia.
2 lbs. sulphate of potash, high grade.
6 lbs. acid phosphate.
100 lbs. muck, air dried.
Plot 47—4 rows (rows 29-33) 1-100 acre.
7 lbs. blood and bone.
5 lbs. potassium-magnesium carbonate.
6 lbs. acid phosphate.
100 lbs. muck, air dried.
Plot 48—4 rows (rows 33-37) 1-100 acre.
1-2 lb. sulphate of ammonia.
5 lbs. potassium-magnesium carbonate.
15 lbs. bone meal.
30 lbs. lime, air slaked.
100 lbs. muck, air dried.
Plot 49—24 rows (rows 37-61) 1-20 acre.
10 lbs. sulphate of ammonia.
20 lbs. sulphate of potash, low grade.
30 lbs. acid phosphate.
Plot 50—24 rows (rows 61-85) 1-20 acre.
2 lbs. sulphate of ammonia.
20 lbs. sulphate of potash, low grade.
80 lbs. bone meal.
Plot 51—24 rows (rows 85-109) 1-20 acre.
10 lbs. sulphate of ammonia.
20 lbs. sulphate of potash, low grade.
30 lbs. acid phosphate.
9 1-4 rows to uncleared land not fertilized.

PLAN OF THE FIELD FOR APPLICATIONS 2 TO 5 (INCLUSIVE.)

After the first application all plots containing twentieth acres (24 rows) were divided into six equal sections lettered from A to F, inclusive, containing as a rule 4 rows (about 1-100 acre). Sections A were treated with a fertilizer containing the normal amount of ammonia, of potash and of phosphoric acid. Sections B were treated with twice the normal amount of ammonia and the normal amount of potash and phosphoric acid. Sections C were treated with the normal amount of ammonia, twice the normal amount of potash, and the normal amount of phosphoric acid. Sections D were treated with the normal amount of ammonia and the normal amount of potash, and twice the normal amount of phosphoric acid. Sections E were treated with one and one-half times the normal amount of the normal formula Sections F. were treated with twice the normal amount of the normal formula.

OBJECT OF THE SECTIONS.

If, therefore, sections A in any particular plot is better than any other section we must conclude that this amount and this combination is better than any other used in the plot.

If section B of any particular plot turns out to be the best section we must conclude that more ammonia from that particular source may be used by the plants than that applied to section A.

If section C in any particular plot is better than any other sections we must conclude that more potash from that particular source than is used in the normal formula, or section A, is needed.

If section D is the best one in that plot we must conclude that more phosphoric acid from that particular source may be used by the plants than is supplied by the normal formula, or section A.

If section E turns out to be the best we must consider the normal formula is practically correct, and that sectfon A did not receive a sufficient amount of fertilizer, while section F received more fertilizer than could be used by the plants.

If section F is the best section of the plot we must conclude that the normal formula is practically correct and that section A and section E have not received as much fertilizer as the plants could use.

If section A is the poorest in the plot we must regard it as due to an insufficient amount of the normal formula of the fertilizer.

If section B turns out poorer than section A, E or F, we must regard it due to an oversupply of that form of ammonia.

If section C is poorer than section A, E or F, we must regard it as due to an over abundance of that form of potash.

If section C is poorer than sections A, E or F, we must consider that too great a quantity of that form of phosphoric acid has been used.

If section D is poorer than section A it is probably due to the application of too much fertilizer; in that case section F would be the poorest in the plot.

FORMULAE FOR

Application 2, June 27 and 28, 1898.

LAND I, 33 PLANTS DEEP.

Plot 1—4 rows (rows 1-4).
18 lbs. cotton seed meal.
Plot 2—4 rows (rows 4-8.)
18 lbs. cotton seed meal.
11 lbs. sulphate of potash, low grade.
Plot 3.—
Section A—4 rows (rows 8-12.)
3 lbs. cotton seed meal.
11 lbs. sulphate of potash, low grade.
31 lbs. bone meal.
Section B—4 rows (rows 12-16.)
21 lbs. cotton seed meal.
11 lbs. sulphate of potash, low grade.
31 lbs. bone meal.
Section C—4 rows (rows 16-20.)
3 lbs. cotton seed meal.
22 lbs. sulphate of potash, low grade.
31 lbs bone meal. t
Section D—4 rows (rows 20-24.)
0 lbs. cotton seed meal.
11 lbs. sulphate of potash, low grade.
62 lbs. bone meal.
Section E—4 rows (rows 24-28.)
4 1-2 lbs. cotton seed meal.
16 lbs. sulphate of potash, low grade.
46 bone meal.
Section F—4 rows (rows 32-36.)
6 lbs. cotton seed meal.
22 lbs. sulphate of potash, low grade.
62 lbs. bone meal.

Plot 4—4 rows (rows 32-36.)
3 lbs. cotton seed meal.
31 lbs. bone meal.

Plot 5—

Section A—4 rows (rows 36-40.)
18 lbs. cotton seed meal.
11 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.

Section B—4 rows (rows 40-44.)
36 lbs. cotton seed meal.
11 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.

Section C—4 rows (rows 44-48.)
18 lbs. cotton seed meal.
22 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.

Section D—4 rows (rows 48-32.)
18 lbs. cotton seed meal.
11lbs. sulphate of potash, low grade.
38 lbs. acid phosphate.

Section E—4 rows (rows 52-56.)
27 lbs. cotton seed meal.
16 lbs. sulphate of potash, low grade.
28 lbs. acid phosphate.

Section F—4 rows (rows 56-60.)
36 lbs. cotton seed meal.
22 lbs. sulphate of potash, low grade.
38 lbs. acid phosphate.

Plot 6—4 rows (rows 60-64.)
18 lbs. cotton seed meal.
19 lbs. acid phosphate.

Plot 7—4 rows (rows 64-68.)
18 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.

Plot 8—

Section A—4 rows (rows 68-72.)
3 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.
31 lbs. bone meal.

Section B—4 rows (rows 72-76.)
21 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.
31 lbs. bone meal.

Section C—4 rows (rows 76-80.)
3 lbs. cotton seed meal.

11 lbs. muriate of potash.
31 lbs. bone meal.
Section D—4 rows (rows 80-84.)
0 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.
62 lbs. bone meal.
Section E—4 rows (rows 84-88.)
4 1-2 lbs. cotton seed meal.
8 lbs. muriate of potash.
46 lbs. bone meal.
Section F—4 rows (rows 88-92.)
6 lbs. cotton seed meal.
11 lbs. muriate of potash.
62 lbs. bone meal.
15 1-2 rows to uncleared land not fertilized.

LAND 2, 33 PLANTS DEEP.

Plot 9—
Section A—4 rows (rows 1-4.)
18 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.
19 lbs. acid phosphate.
Section B—3 rows (rows 4-7.)
36 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.
19 lbs. acid phosphate.
Section C—4 rows (rows 7-11.)
18 lbs. cotton seed meal.
11 lbs. muriate of potash.
19 lbs. acid phosphate.
Section D—4 rows (rows 11-15.)
18 lbs. cotton seed meal.
5 1-2 lbs. muriate of potash.
38 lbs. acid phosphate.
Section E—4 rows (rows 15-19.)
27 lbs. cotton seed meal.
8 lbs. muriate of potash.
28 lbs. acid phosphate.
Section F—4 rows (rows 19-23.)
36 lbs. cotton seed meal.
11 lbs. muriate of potash.
38 lbs. acid phosphate.

Plot 10—4 rows (rows 27-31.)
18 lbs. cotton seed meal.
21 lbs. kainit.

Plot 11—
Section A—4 rows (rows 27-31.)
3 lbs. cotton seed meal.
21 lbs. kainit.
31 lbs. bone meal.
Section B—4 rows (rows 31-35.)
21 lbs. cotton seed meal.
21 lbs. kainit.
31 lbs. bone meal.
Section C—4 rows (rows 35-39.)
3 lbs. cotton seed meal.
42 lbs. kainit.
31 lbs. bone meal.
Section D—4 rows (rows 39-43.)
0 lbs. cotton seed meal.
21 lbs. kainit.
62 lbs. bone meal.
Section E—4 rows (rows 43-47.)
4 1-2 lbs. cotton seed meal.
31 lbs. kainit.
46 lbs. bone meal.
Section F—4 rows (rows 47-51.)
6 lbs. cotton seed meal.
42 lbs. kainit.
62 lbs. bone meal.

Plot 12—
Section A—4 rows (rows 51-55.)
18 lbs. cotton seed meal.
21 lbs. kainit.
19 lbs. acid phosphate.
Section B—4 rows (rows 55-59.)
36 lbs. cotton seed meal.
21 lbs. kainit.
19 lbs. acid phosphate.
Section C—4 rows (rows 59-63.)
18 lbs. cotton seed meal.
42 lbs. kainit.
19 lbs. acid phosphate.
Section D—4 rows (rows 63-67.)
18 lbs. cotton seed meal.
21 lbs. kainit.
38 lbs. acid phosphate.

Section E—4 rows (rows 67-71.)
27 lbs. cotton seed meal.
31 lbs. kainit.
28 lbs. acid phosphate.
Section F—4 rows (rows 71-75.)
36 lbs. cotton seed meal.
42 lbs. kainit.
38 lbs. acid phosphate.
Plot 13—4 rows (rows 75-79.)
18 lbs. cotton seed meal.
15 1-2 lbs. potassium-magnesium carbonate.
31 lbs. bone meal (mistake made by laborer.)
Plot 14—
Section A—4 rows (rows 79-83.)
3 lbs. cotton seed meal.
15 1-2 lbs. potassium-magnesium carbonate.
31 lbs. bone meal.
Section B—4 rows (rows 83-87.)
21 lbs. cotton seed meal.
15 1-2 lbs. potassium-magnesium carbonate.
31 lbs. bone meal (laborer's inadvertance.)
Section C—4 rows (rows 87-91.)
3 lbs. cotton seed meal.
31 lbs. potassium-magnesium carbonate.
31 lbs. bone meal.
Section D—4 rows (rows 91-95.)
0 lbs. cotton seed meal.
15 1-2 lbs. potassium-magnesium carbonate.
62 lbs. bone meal.
Section E—4 rows (rows 95-99.)
4 1-2 lbs. cotton seed meal.
23 lbs. potassium-magnesium carbonate.
46 lbs. bone meal.
Section F—4 rows (rows 99-103.)
6 lbs. cotton seed meal.
31 lbs. potassium-magnesium carbonate.
62 lbs. bone meal.
5 rows to uncleared land not fertilized.

LAND 3, 33 PLANTS DEEP.

Plot 15—
Section A—4 rows (rows 1-4.)
18 lbs. cotton seed meal.
15 1-2 lbs. potassium-magnesium carbonate.

19 lbs. acid phosphate.

Section B—4 rows (rows 4-8.)

36 lbs. cotton seed meal.

15 1-2 lbs. potassium-magnesium carbonate.

19 lbs. acid phosphate.

Section C—4 rows (rows 8-12.)

18 lbs. cotton seed meal.

31 lbs. potassium-magnesium carbonate.

19 lbs. acid phosphate.

Section D—4 rows (rows 12-16.)

18 lbs. cotton seed meal.

15 1-2 lbs. potassium-magnesium carbonate.

38 lbs. acid phosphate.

Section E—4 rows (rows 16-20.)

27 lbs. cotton seed meal.

23 lbs. potassium-magnesium carbonate.

28 lbs. acid phosphate.

Section F—5 rows (rows 20-25.)

36 lbs. cotton seed meal.

31 lbs. potassium-magnesium carbonate.

38 lbs. acid phosphate.

Plot 16—4 rows (rows 25-29.)

18 lbs. cotton seed meal.

6 lbs. sulphate of potash, high grade.

Plot 17—

Section A—4 rows (rows 29-33.)

3 lbs. cotton seed meal.

6 lbs. sulphate of potash, high grade.

31 lbs. bone meal.

Section B—3 rows (rows 33-36.)

21 lbs. cotton seed meal.

6 lbs. sulphate of potash, high grade.

31 lbs. bone meal.

Section C—3 rows (rows 36-39.)

3 lbs. cotton seed meal.

12 lbs. sulphuate of potash, high grade.

31 lbs. bone meal.

Section D—4 rows (rows 39-43.)

0 lbs. cotton seed meal.

6 lbs. sulphate of potash, high grade.

62 lbs. bone meal.

Section E—4 rows (rows 43-47.)

4 1-2 lbs. cotton seed meal.

9 lbs. sulphate of potash, high grade .

46 lbs. bone meal.

Section F—4 rows (rows 47-51.)
6 lbs. cotton seed meal.
12 lbs. sulphate of potash, high grade.
62 lbs. bone meal.

Plot 18—

Section A—4 rows (rows 51-55.)
18 lbs. cotton seed meal.
6 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.

Section B—4 rows (rows 55-59.)
36 lbs. cotton seed meal.
6 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.

Section C—4 rows (rows 59-63.)
18 lbs. cotton seed meal.
12 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.

Section D—4 rows (rows 63-67.)
18 lbs. cotton seed meal.
6 lbs. sulphate of potash, high grade.
38 lbs. acid phosphate.

Section E—4 rows (rows 67-71.)
27 lbs. cotton seed meal.
9 lbs. sulphate of potash, high grade.
28 lbs. acid phosphate.

Section F—4 rows (rows 71-75.)
36 lbs. cotton seed meal.
12 lbs. sulphate of potash, high grade.
38 lbs. acid phosphate.

Plot 19—4 rows (rows 75-79.)
5 1-2 lbs. sulphate of ammonia.

Plot 20—4 rows (rows 79-83.)
5 1-2 lbs. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.

Plot 21—

Section A—4 rows (rows 83-87.)
1 lb. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.
31 lbs. bone meal.

Section B—4 rows (rows 87-91.)
6 1-2 lbs. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.
31 lbs. bone meal.

Section C—4 rows (rows 91-95.)
1 lb. sulphate of ammonia.

12 lbs. sulphate of potash, high grade.
31 lbs. bone meal.

Section D—4 rows (rows 95-99.)
0 lbs. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.
62 lbs. bone meal.

Section E—4 rows (rows 99-103.)
1 1-2 lbs. sulphate of ammonia.
9 lbs. sulphate of potash, high grade.
46 lbs. bone meal.

Section F—4 rows (rows 103-107.)
2 lbs. sulphate of ammonia.
12 lbs. sulphate of potash, high grade.
62 lbs. bone meal.

Sand from ditch thrown into rows 3 and 4.

2 and 1-4 rows to uncleared land not fertilized.

LAND 4, 33 PLANTS DEEP.

Plot 22—

Section A—4 rows (rows 1-4.)
1 lb. sulphate of ammonia.
5 1-2 lbs. muriate of potash.
31 lbs. bone meal.

Section B—4 rows (rows 4-8.)
6 1-2 lbs. sulphate of ammonia.
5 1-2 lbs. muriate of potash.
31 lbs. bone meal.

Section C—4 rows (rows 8-12.)
1 lb. sulphate of ammonia.
11 lbs. muriate of potash.
31 lbs. bone meal.

Section D—4 rows (rows 12-16.)
0 lbs. sulphate of ammonia.
5 1-2 lbs. muriate of potash.
62 lbs. bone meal.

Section E—4 rows (rows 16-20.)
1 1-2 lbs. sulphate of ammonia.
8 lbs. muriate of potash.
46 lbs. bone meal.

Section F—4 rows (rows 20-24.)
2 lbs. sulphate of ammonia.
11 lbs. muriate of potash.
62 lbs. bone meal.

Plot 23—

Section A—4 rows (rows 24-28.)
5 1-2 lbs. sulphate of ammonia.
5 1-2 lbs. muriate of potash.
19 lbs. acid phosphate.

Section B—4 rows (rows 28-32.)
11 lbs. sulphate of ammonia.
5 1-2 muriate of potash.
19 lbs. acid phosphate.

Secton C—4 rows (rows 32-36.)
5 1-2 lbs. sulphate of ammonia.
11 lbs. muriate of potash.
19 lbs. acid phosphate.

Section D—4 rows (rows 36-40.)
5 1-2 lbs. sulphate of ammonia
5 1-2 lbs. muriate of potash.
38 lbs. acid phosphate.

Section E—4 rows (rows 40-44.)
8 lbs. sulphate of ammonia.
8 lbs. muriate of potash.
28 lbs. acid phosphate.

Section F—4 rows (rows 44-48.)
11 lbs. sulphate of ammonia.
11 lbs. Muriate of potash.
38 lbs. acid phosphate.

Plot 24—

Section A—4 rows (rows 48-52.)
1 lb. sulphate of ammonia.
21 lbs. kainit.
31 lbs. bone meal.

Section B—4 rows (rows 52-56.)
6 1-2 lbs. sulphate of ammonia.
21 lbs. kainit.
31 lbs. bone meal.

Section C—4 rows (rows 56-60.)
1 lb. sulphate of ammonia.
42 lbs. kainit.
31 lbs. bone meal.

Section D—4 rows (rows 60-64.)
0 lbs. sulphate of ammonia.
21 lbs. kainit.
62 lbs. bone meal.

Section E—4 rows (rows 64-68.)
1 1-2 lbs. sulphate of ammonia.
31 lbs. kainit.

46 lbs. bone meal.
Section F—4 rows (rows 68-72.)
2 lbs. sulphate of ammonia.
42 lbs. kainit.
62 lbs. bone meal.

Plot 25—
Section A—4 rows (rows 72-76.)
5 1-2 lbs. sulphate of ammonia.
21 lbs. kainit.
19 lbs. acid phosphate.
Section B—4 rows (rows 76-80.)
11 lbs. sulphate of ammonia.
21 lbs. kainit.
19 lbs. acid phosphate.
Section C—4 rows (rows 80-84.)
5 1-2 lbs. sulphate of ammonia.
42 lbs. kainit.
19 lbs. acid phosphate.
Section D—4 rows (rows 84-88.)
5 1-2 lbs. sulphate of ammonia.
21 lbs. kainit.
38 lbs. acid phosphate.
Section E—4 rows (rows 88-92.)
8 lbs. sulphate of ammonia.
31 lbs. kainit.
28 lbs. acid phosphate.
Section F—4 rows (rows 92-96.)
11 lbs. sulphate of ammonia.
42 lbs. kainit.
38 lbs. acid phosphate.
15 rows to uncleared land not fertilized.

LAND 5, 33 PLANTS DEEP.

Plot 26—
Section A—4 rows (rows 1-4.)
5 1-2 lbs. sulphate of ammonia.
15 1-2 lbs. potassium-magnesium carbonate.
19 lbs. acid phosphate.
Section B—4 rows (rows 4-8.)
11 lbs. sulphate of ammonia.
15 1-2 lbs. potassium-magnesium carbonate.
19 lbs. acid phosphate.

Section C—4 rows (rows 8-12.)
5 1-2 lbs. sulphate of ammonia.
31 lbs. potassium-magnesium carbonate.
19 lbs. acid phosphate.
Section D—4 rows (rows 12-16.)
5 1-2 lbs. sulphate of ammonia.
15 1-2 lbs. potassium-magnesium carbonate.
38 lbs. acid phosphate.
Section E—4 rows (rows 16-20.)
8 lbs. sulphate of ammonia.
23 lbs. potassium-magnesium carbonate.
28 lbs. acid phosphate.
Section F—4 rows (rows 20-24.)
11 lbs. sulphate of ammonia.
31 lbs. potassium-magnesium carbonate.
38 lbs. acid phosphate.
Plot 27—4 rows (rows 24-28.)
7 lbs. nitrate of soda.
Plot 28—4 rows (rows 28-32.)
7 lbs. nitrate of soda.
6 lbs. sulphate of potash, high grade.
Plot 29—
Section A—4 rows (rows 32-36.)
7 lbs. nitrate of soda.
6 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.
Section B—4 rows (rows 36-40.)
14 lbs. nitrate of soda.
6 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.
Section C—4 rows (rows 40-44.)
7 lbs. nitrate of soda.
12 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.
Section D—4 rows (rows 44-48.)
7 lbs. nitrate of soda.
6 lbs. sulphate of potash, high grade.
38 lbs. acid phosphate.
Section E—4 rows (rows 48-52.)
10 1-2 lbs. nitrate of soda.
9 lbs. sulphate of potash, high grade.
28 lbs. acid phosphate.
Section F—4 rows (rows 52-56.)
14 lbs. nitrate of soda.
12 lbs. sulphate of potash, high grade.

38 lbs. acid phosphate.

Plot 30—

Section A—4 rows (rows 56-60.)
7 lbs. nitrate of soda.
5 1-2 lbs. muriate of potash.
19 lbs. acid phosphate.

Section B—4 rows (rows 60-64.)
14 lbs. nitrate of soda.
5 1-2 lbs. muriate of potash.
19 lbs. acid phosphate.

Section C—4 rows (rows 64-68.)
7 lbs. nitrate of soda.
11 lbs. muriate of potash.
19 lbs. acid phosphate.

Section D—4 rows (rows 68-72.)
7 lbs. nitrate of soda.
5 1-2 lbs. muriate of potash.
38 lbs. acid phosphate.

Section E—4 rows (rows 72-76.)
10 1-2 lbs. nitrate of soda.
8 lbs. muriate of potash.
28 lbs. acid phosphate.

Section F—4 rows (rows 76-80.)
14 lbs. nitrate of soda.
11 lbs. muriate of potash.
38 lbs. acid phosphate.

Plot 31—

Section A—4 rows (rows 80-84.)
7 lbs. nitrate of soda.
11 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.

Section B—4 rows (rows 84-88.)
14 lbs. nitrate of soda.
11 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.

Section C—4 rows (rows 88-92.)
7 lbs. nitrate of soda.
22 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.

Section D—4 rows (rows 92-96.)
7 lbs. nitrate of soda.
11 lbs. sulphate of potash, low grade.
38 lbs. acid phosphate.

Section E—4 rows (rows 96-100.)
10 1-2 lbs. nitrate of soda.
16 lbs. sulphate of potash, low grade.
28 lbs. acid phosphate.
Section F—4 rows (rows 100-104.)
14 lbs. nitrate of soda.
22 lbs. sulphate of potash, low grade.
38 lbs. acid phosphate.
7 rows to uncleared land not fertilized.

LAND 6, 29 PLANTS DEEP.

Plot 32—
Section A—4 rows (rows 1-4.)
6 lbs. nitrate of soda.
19 lbs. kainit.
17 lbs. acid phosphate.
Section B—4 rows (rows 4-8.)
12 lbs. nitrate of soda.
19 lbs. kainit.
17 lbs. acid phosphate.
Section C—4 rows (rows 8-12.)
6 lbs. nitrate of soda.
38 lbs. kainit.
17 lbs. acid phosphate.
Section D—4 rows (rows 12-16.)
6 lbs. nitrate of soda.
19 lbs. kainit.
34 lbs. acid phosphate.
Section E—4 rows (rows 16-20.)
9 lbs. nitrate of soda.
28 lbs. kainit.
25 lbs. acid phosphate.
Section F—4 rows (rows 20-24.)
12 lbs. nitrate of soda.
38 lbs. kainit.
34 lbs. acid phosphate.
Plot 33—
Section A—4 rows (rows 24-28.)
6 lbs. nitrate of soda.
13 1-2 lbs. potassium-magnesium carbonate.
17 lbs. acid phosphate.
Section B—4 rows (rows 28-32.)
12 lbs. nitrate of soda.

13 1-2 lbs. potassium-magnesium carbonate.
17 lbs. acid phosphate.

Section C—4 rows (rows 32-36.)
6 lbs. nitrate of soda.
27 lbs. potassium-magnesium carbonate.
17 lbs. acid phosphate.

Section D—4 rows (rows 36-40.)
6 lbs. nitrate of soda.
13 1-2 lbs. potassium-magnesium carbonate.
34 lbs. acid phosphate.

Section E—4 rows (rows 40-44.)
9 lbs. nitrate of soda.
20 lbs. potassium-magnesium carbonate.
25 lbs. acid phosphate.

Section F—4 rows (rows 44-48.)
12 lbs. nitrate of soda.
27 lbs. potassium-magnesium carbonate.
34 lbs. acid phosphate.

Plot 34—

Section A—8 rows (rows 48-56.)
31 lbs. blood and bone.

Section B—8 rows (rows 56-64.)
41 lbs. blood and bone.

Section C—8 rows (rows 64-72.)
62 lbs. blood and bone.

Plot 35—

Section A—4 rows (rows 72-76.)
15 1-2 lbs. blood and bone.
5 1-2 lbs. sulphate of potash, high grade.

Section B—4 rows (rows 76-80.)
33 lbs. blood and bone.
5 1-2 lbs. sulphate of potash, high grade.

Section C—5 rows (rows 80-85.)
19 lbs. blood and bone.
14 lbs. sulphate of potash, high grade.

Section D—5 rows (rows 85-90.)
28 lbs. blood and bone.
10 lbs. sulphate of potash, high grade.

Section E—5 rows (rows 90-95.)
38 lbs. blood and bone.
14 lbs. sulphate of potash, high grade.

15 rows, 3-4 row and 1-4 row to uncleared land not fertilized.

LAND 7, 29 PLANTS DEEP.

2 short rows not fertilized.

Plot 36—

Section A—4 rows (rows 1-4).
15 1-2 lbs. blood and bone.
11 lbs. sulphate of potash, low grade.

Section B—5 rows (rows 4-9.)
38 lbs. blood and bone.
14 lbs. sulphate of potash, low grade.

Section C—5 rows (rows 9-14.)
19 lbs. blood and bone.
28 lbs. lbs. sulphate of potash, low grade.

Section D—5 rows (rows 14-19.)
28 lbs. blood and bone.
20 lbs. sulphate of potash, low grade.

Section E—5 rows (rows 43-48.)
38 lbs. blood and bone.
28 lbs. sulphate of potash, low grade.

Plot 37—

Section A—4 rows (rows 24-28.)
15 1-2 lbs. blood and bone.
19 lbs. kainit.

Section B—5 rows (rows 28-33.)
38 lbs. blood and bone.
24 lbs. kainit.

Section C—5 rows (rows 33-38.)
19 lbs. blood and bone.
48 lbs. kainit.

Section D—5 rows (rows 38-43.)
28 lbs. blood and bone.
36 lbs. kainit

Section E—5 rows (rows 48-52.)
38 lbs. blood and bone.
48 lbs. kainit.

Plot 38—

Section A—4 rows (rows 72-76.)
15 1-2 lbs. blood and bone.
5 1-2 lbs. muriate of potash.

Section B—5 rows (rows 52-57.)
38 lbs. blood and bone.
7 lbs. muriate of potash.

Section C—5 rows (rows 57-62.)
19 lbs. blood and bone.
14 lbs. muriate of potash.

Section D—5 rows (rows 62-67.)
28 lbs. blood and bone.
10 1-2 lbs. muriate of potash.
Section E—5 rows (rows 67-72.)
38 lbs. blood and bone.
14 lbs. muriate of potash.
Plot 39—
Section A—4 rows (rows 72-76.)
15 1-2 lbs. blood and bone.
13 1-2 lbs. potassium-magnesium carbonate.
Section B—5 rows (rows 76-81.)
38 lbs. blood and bone.
17 lbs. potassium-magnesium carbonate.
Section C—5 rows (rows 81-86.)
19 lbs. blood and bone.
34 lbs. potassium-magnesium carbonate.
Section D—5 rows (rows 86-91.)
28 lbs. blood and bone.
25 lbs. potassium-magnesium carbonate.
Section E—5 rows (rows 91-96.)
38 lbs. blood and bone.
34 lbs. potassium-magnesium carbonate.
18 1-2 rows to uncleared land not fertilized.

LAND 8, 32 PLANTS DEEP.

Plot 40—5 rows (rows 1-5.)
21 lbs. cotton seed meal.
7 lbs. sulphate of potash, high grade.
18 lbs. acid phosphate.
0 lbs. lime, air slaked.
Plot 41—4 rows (rows 5-9.)
8 lbs. nitrate of soda.
20 lbs. kainit.
18 lbs. acid phosphate.
0 lbs. lime, air slaked.
Plot 42—4 rows (rows 9-13.)
5 lbs. sulphate of ammonia.
5 1-2 lbs. sulphate of potash, high grade.
18 lbs. acid phosphate.
0 lbs. lime, air slaked.
Plot 43—4 rows (rows 13-17.)
17 lbs. blood and bone.

15 lbs. potassium-magnesium carbonate.
18 lbs. acid phosphate.
0 lbs. lime, air slaked.
Plot 44—4 rows (rows 17-21.)
17 lbs. cotton seed meal.
5 1-2 lbs. sulphate of potash, high grade.
18 lbs. acid phosphate.
0 lbs. muck, air dried.
Plot 45—4 rows (rows 21-25.)
8 lbs. nitrate of soda.
20 lbs. kainit.
18 lbs. acid phosphate.
0 lbs. muck, air dried.
Plot 46—4 rows (rows 25-29.)
5 lbs. sulphate of ammonia.
5 1-2 lbs. sulphate of potash, high grade.
18 lbs. acid phosphate.
0 lbs. muck, air dried.
Plot 47—4 rows (rows 29-33.)
17 lbs. blood and bone.
15 lbs. potassium-magnesium carbonate.
18 lbs. acid phosphate.
0 lbs. muck, air dried.
Plot 48—4 rows (rows 33-37.)
5 lbs. sulphate of ammonia.
15 lbs. potassium-magnesium carbonate.
31 lbs. bone meal.
0 lbs. lime, air slaked.
0 lbs. muck, air dried.

Plot 49—
Section A—4 rows (rows 37-41.)
5 1-2 lbs. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.
Section B—4 rows (rows 41-45.)
11 lbs. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.
Section C—4 rows (rows 45-49.)
5 1-2 lbs. sulphate of ammonia.
12 lbs. sulphate of potash, high grade.
19 lbs. acid phosphate.
Section D—4 rows (rows 49-53.)
5 1-2 lbs. sulphate of ammonia.
6 lbs. sulphate of potash, high grade.

38 lbs. acid phosphate.
Section E—4 rows (rows 53-57.)
8 lbs. sulphate of ammonia.
9 lbs. slulphate of potash, high grade.
28 lbs. acid phosphate.
Section F—4 rows (rows 57-61.)
11 lbs. sulphate of ammonia.
12 lbs. sulphate of potash, high grade
38 lbs. acid phosphate.

Plot 50—
Section A—4 rows (rows 61-65.)
1 lb. sulphate of ammonia.
11 lbs. sulphate of potash, low grade.
31 lbs. bone meal.
Section B—4 rows (rows 65-69.)
6 1-2 lbs. sulphate of ammonia.
11 lbs. sulphate of potash, low grade.
31 lbs. bone meal.
Section C—4 rows (rows 69-75.)
1 lb. sulphate of ammonia.
22 lbs. sulphate of potash, low grade.
31 lbs. bone meal.
Section D—4 rows (rows 73-77.)
0 lbs. sulphate of ammonia.
11 lbs. sulphate of potash, low grade.
62 lbs. bone meal.
Section E—4 rows (rows 77-81.)
1 1-2 lbs. sulphate of ammonia.
16 lbs. sulphate of potash, low grade.
46 lbs. bone meal.
Section F—4 rows (rows 81-85.)
2 lbs. sulphate of ammonia.
22 lbs. sulphate of potash, low grade.
62 lbs. bone meal.

Plot 51—
Section A—4 rows (rows 85-89.)
5 1-2 lbs. sulphate of ammonia.
11 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.
Section B—4 rows (rows 89-93.)
11 lbs. sulphate of potash, low grade.
19 lbs. acid phosphate.
Section C—4 rows (rows 93-97.)
5 1-2 lbs. sulphate of ammonia.
22 lbs. sulphate of potash, low grade.

19 lbs. acid phosphate.
Section D—4 rows (rows 97-101.)
5 1-2 lbs. sulphate of ammonia.
11 lbs. sulphate of potash, low grade.
38 lbs. acid phosphate.
Section E—4 rows (rows 101-105.)
8 lbs. sulphate of ammonia.
16 lbs. sulphate of potash, low grade.
28 lbs. acid phosphate.
Section F—4 rows (rows 105-109.)
11 lbs. sulphate of ammonia.
22 lbs. sulphate of potash, low grade.
38 lbs. acid phosphate.
9 1-2 rows to uncleared land not fertilized.

SIZE OF THE PLOTS.

In the beginning of the experiments it was thought that the plots which contain one hundredth acre would be too small to give very definite information, but by referring to the plates at the close of this bulletin it will be seen that no difficulty is experienced in this way. It goes without saying that a more definite conclusion would be reached by using one-tenth acre plots in the place of one-hundredth acre plots, but this would really have placed the work beyond the reach of the Experiment Station, and those who were undertaking it. The variation due to different fertilizers in the various plots has been so decided that there can be no doubt as to the desirability of using one-hundredth acre plots, or smaller plots, in preliminary experiments upon pineapples. By referring to the various plates illustrating the plots, taking for example the one on which plot 29 is represented we notice that the change in the fertilizer makes a decided change in the size of the pineapple plants, to the row. By turning to the plate upon which plot 22 and plot 23 may be seen we will notice that the stake row, which is fertilized on one side by formula 23 and on the other side by 22 occupies quite an intermediate position between the two plots and the size of the plants is about intermediate. A more sharply defined intermediate may be seen by referring to the plate illustrating plots 12 and 13. By turning to plate upon which are represented plots 49 and 50 and by counting 4 rows to the right from the stake we notice that section F in plot 29 is sharply defined from section E. This section (F) was treated with the same fertilizer as section E, section E receiving one and one-half times the normal amount of the normal fertilizer, while section F received two times the amount of the identical formula and the identical fertilizer.

The whole series of experiments came out in such a decided and positive way that the conclusions are not based on hair-splitting differences. Referring to such plots as 12, 23 and 29 and contrasting them with the adjoining plots, we can readily see that the first 4 rows tell a sufficient tale. We can see scarcely any perceptible difference between the second, the third and the fourth rows in any section. The same is true of every section in the entire field of nearly 200 divisions. As the first fertilizer was applied in Feb., 1898, and these photographs taken in July, 1899, we can see that the fertilizer had plenty of time to spread through the soil if there was to be such a process. In many cases fine plots were located towards the top of the hill from plots that were very poor, as in the case of 38 and 39 being located above 49 and 51, yet no change in these plots (49 and 51) could be attributed to the fertilizer leaching through the soil. Plot 29, a very poor one, was located just above plot 34 without detriment to the latter. Plot 30, a sixth class plot, was located above plot 35, a first class plot, yet no change could be noticed in the plants in plot 35 that would lead one to believe that the fertilizer was leached from plot 30 to 35.

From a general review of these plots one is forced to the conclusion that one-hundredth acre plots are abundantly large for preliminary tests in pineapple fertilizers. The soil does not permit of checks being placed between different plots. Otherwise for preliminary purposes the plots might be one-half the size of those used, thus materially reducing the expense of the experiments. Under the existing conditions it is quite probable that the plots might have been shortened 25 or 50 per cent. and yet give definite information.

FERTILIZER EFFECTING LEAF AREA.

The effect of fertilizer upon young plants is somewhat different than it is upon fruiting plants. The observations on leaf area were taken on November 12, 1898. Observations were again taken on January 8, 1899, giving practically the same results as those on November 12, 1898. That is the plants from November 12 to January 8 had made no marked progress in growth, nor had there been any noticeable change in the relative growth of the different plots.

To obtain the relative positions in the following table leaves in various plots were measured. The area was obtained by measuring the width of the leaves at the base and then their length, then multiplying the length by the breadth of the base and dividing by two. Although this does not give us the exact area of the upper surface of the leaf, it approximates so closely that for the sake of comparison and all practical purposes, it is sufficiently correct.

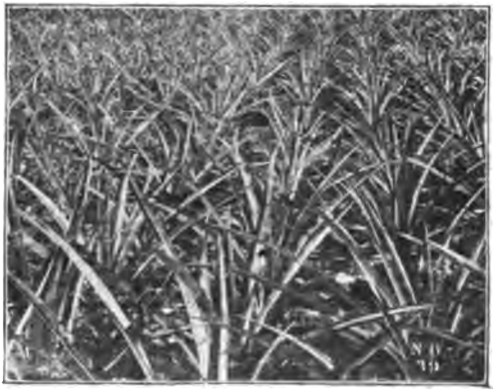


Fig. 1.—1st Class Plot.—Blood and Bone and Potassium-Magnesium Carbonate.

Those plots whose leaves showed an average of 40 to 34 square inches per leaf on the upper surface were put in class one.

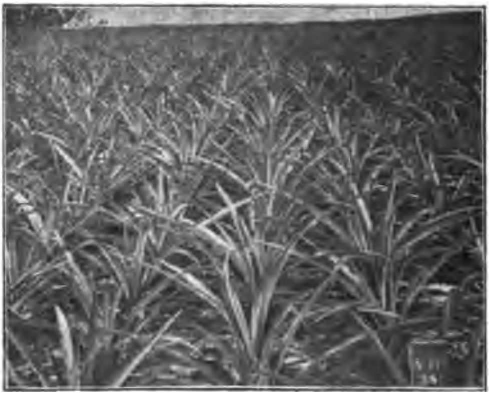


Fig. 2.—2nd Class Plot.—Blood and Bone and Muriate of Potash.

Those plots whose average leaf surface showed an area of 34 to 30 square inches were put in class two.

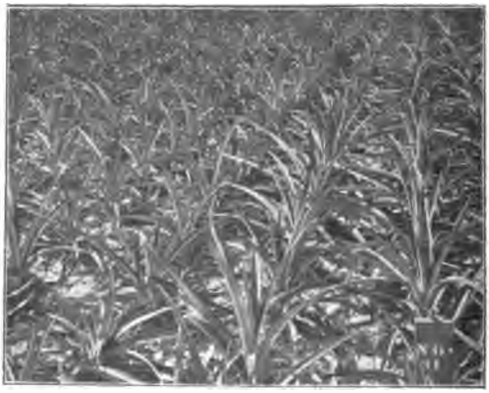


Fig. 3.—2nd Class Plot.—Nitrate of Soda, Low Grade Sulphate of Potash and Acid Phosphate.

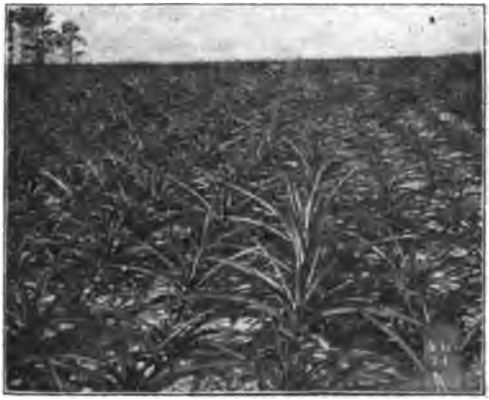


Fig. 4.—3rd Class Plot—Sulphate of Ammonia, Kainit and Bone Meal.

Those plots whose average leaves showed an area of 30 to 26 square inches were put in class three.

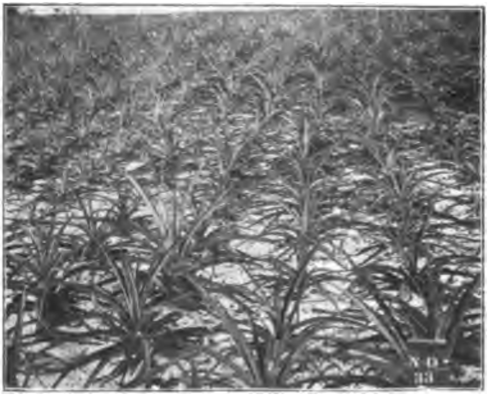


Fig. 5.—4th Class Plot.—Nitrate of Soda, Potassium-Magnesium Carbonate and Acid Phosphate.

Those plots whose leaves showed an average of 26 to 22 square inches were put in class four.

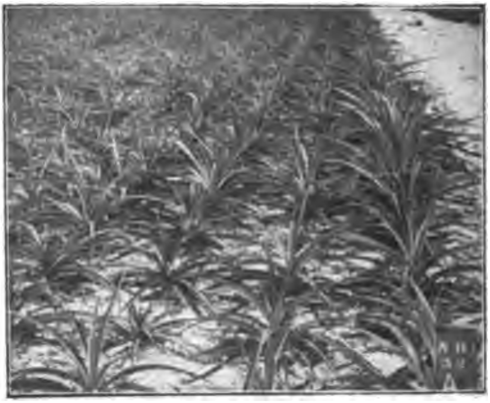


Fig. 6.—4th Class Plot.—Nitrate of Soda. Kainit and Acid **Phosphate.**

Those plots whose average leaves gave an area of 22 to 18 square inches were put in class five.

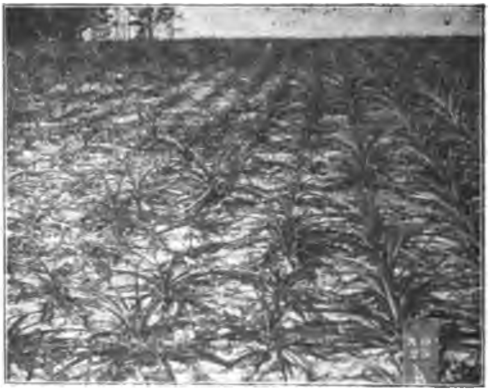


Fig. 7.—5th Class Plot.—Sulphate of Ammonia. Kainit and **Acid Phosphate.**

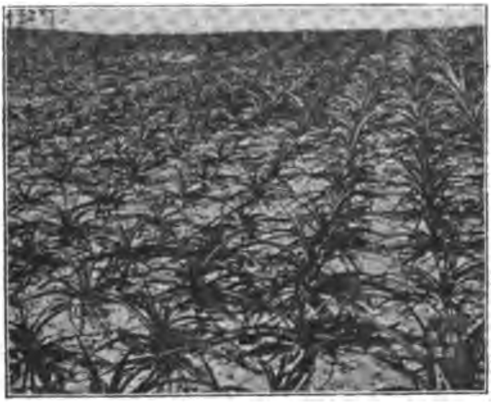


Fig. 8.—6th Class Plot.—Sulphate of Ammonia, Muriate of Potash and Acid Phosphate.

Those plots whose average leaves gave an area of less than 18 square inches were put in class six.

By adopting the above standard blood and bone was found to give us the largest leaf area, or approximately an average of 34.6 square inches per leaf. The plots fertilized with nitrate of soda gave an average of 23.6 square inches. Those plots fertilized with cotton seed meal gave an average of 23.2. Those fertilized with sulphate of ammonia 22.4. It will thus be seen that blood and bone produced plants with a much larger leaf surface than either nitrate of soda, cotton seed meal or sulphate of ammonia.

Considering the different forms of potash we find that potassium-magnesium carbonate stands at the head with an average of 30.8 square inches to the average leaf. Sulphate of potash, low grade, coming second with an average of 28.8 square inches, muriate of potash standing next with an average of 28.4 square inches, sulphate of potash, high grade, coming fourth with an average of 28 square inches, and kainit coming last with an average of 25.6 square inches.

The difference in the average leaf surfaces between those plots fertilized with bone meal and those fertilized with acid phosphate comes out more strikingly than any other of the ingredients used. The average of those fertilized with bone meal being

32.4 square inches, while those fertilized with acid phosphate gave anly an average of 25.2 square inches.

In short, then, when we are fertilizing young pines for leaf area, or to obtain vigorous growth, as a source of ammonia we would find that blood and bone give the best results. Next to this nitrate of soda, then cotton seed meal, and the poorest results were obtained from sulphate of ammonia. In the use of potash we find that the carbonate stands highest, sulphate of potash, low grade, second; muriate of potash, third; sulphate of potash, high grade, fourth; kainit last. Bone meal seems to give an abundant supply of phosphoric acid.

Comparing those plots with incomplete fertilizers we find that where no potash was used the leaf surface averaged 28 square inches per leaf, while the average of the plots fertilized with complete fertilizers gave an average of 28.3 square inches.

Kainit on the average fell to 25.6 square inches, indicating that the plots which received no potash did better than when kainit had been added, thus indicating very clearly that kainit is worse than useless.

Those plots to which no phosphoric acid had been supplied gave an average leaf surface of 26.8 square inches, while the average leaf surface of the plots fertilized with a complete fertilizer gave 28.8 square inches, showing very clearly that the soil was likwise deficient in phosphoric acid. Those plots treated with acid phosphate gave an average leaf area of 25.2 square inches, showing that this substance was worse than useless.

The plots fertilized with ammonia alone gave an average of 26 square inches.

In the connection with incomplete fertilizers there were some very interesting plots. Number 27, which received only nitrate of soda, gave an average of 37 square inches leaf surface. Number 28, which had in addition to the nitrate of soda sulphate of potash, high grade, gave the same size leaf surface. Plot 27 was very severely injured by the freeze, while 28 came through better.

Plot number 19, fertilized with sulphate of ammonia, gave only 16.5 square inches of leaf surface. Number 20, fertilized with sulphate of ammonia and sulphate of potash, high grade, gave the same size leaf surface. Plot number 34, fertilized with blood and bone, having the largest leaf area, was very severely injured by the freeze, fell to the second class plot by July 6, 1899. Plot number 14 stood second in size leaf area and fertilized with cotton seed meal, bone meal and potassium-magnesium carbonate was only slightly injured by the freeze, but fell to the third class plot by July, 1899.

TABLE SHOWING RELATIVE LEAF AREA. INCOMPLETE FERTILIZER.—NOV. 12, 1898.

NO POTASH.

Plot	1	2	3	4	5	6
1				*		
4				*		
6					*	
19						*
27	*					
34	*					

NO PHOSPHORIC ACID.

Plot	1	2	3	4	5	6
1				*		
2					*	
7					*	

NO PHOS. ACID CONT'D.

Plot	1	2	3	4	5	6
10					*	
13	*					
16			*			
19						*
20						*
27	*					
28	*					

NEITHER POT. NOR PHOS.

Plot	1	2	3	4	5	6
1				*		
19						*
27	*					

TABLE SHOWING RELATIVE LEAF AREA.—AMMONIAS COMPARED.—NOV. 12, 1898.

COTTON SEED MEAL.

Plot	1	2	3	4	5	6
1				*		
2					*	
3					*	
4				*		
5					*	
6					*	
7				*		
8		*				
9					*	
10					*	
11		*				
12				*		
13	*					
14	*					
15					*	
16			*			
17					*	
18					*	
40			*			
44	*					

SULPHATE AMMONIA.

Plot	1	2	3	4	5	6
19						*
20						*
21				*		
22		*				
‡23						*
‡24			*			
‡25					*	

SUL. AMMONIA CONT'D.

	1	2	3	4	5	6
26					*	
42			*			
46					*	
48	*					
49			*			
50		*				
51			*			

NITRATE OF SODA.

Plot	1	2	3	4	5	6
27	*					
28	*					
29					*	
30			*			
‡31		*				
‡32				*		
‡33				*		
41						*
45						*

BLOOD AND BONE.

Plot	1	2	3	4	5	6
34	*					
35	*					
36	*					
37		*				
‡38		*				
‡39	*					
43			*			
47				*		

§See illustration on previous page. Photographed November, 1898.

TABLE SHOWING RELATIVE LEAF AREA.—POTASHES COMPARED.—NOV. 12, 1898.

KAINIT.

Plot	1	2	3	4	5	6
10					*	
11		*				
12				*		
‡24			*			
‡25					*	
‡32				*		
37		*				
41						*
45						*

SUL. POTASH, L. G.

Plot	1	2	3	4	5	6
2					*	
3					*	
5					*	
‡31		*				
36	*					
50		*				
51			*			

SUL. POTASH, H. G.

Plot	1	2	3	4	5	6
16			*			
17					*	
18					*	
20						*
21				*		
28	*					
29					*	
35	*					

SUL. POTASH, H. G., CONT'D.

Plot	1	2	3	4	5	6
40			*			
42			*			
44	*					
46					*	
49			*			

MURIATE OF POTASH.

Plot	1	2	3	4	5	6
7				*		
8		*				
9					*	
22		*				
‡23						*
30			*			
‡38		*				

POT.-MAG. CARBONATE.

Plot	1	2	3	4	5	6
13	*					
14	*					
15					*	
26					*	
‡33				*		
‡39	*					
43			*			
47				*		
48	*					

§See illustration on previous page. Photographed November, 1898.

TABLE SHOWING RELATIVE LEAF AREA.—AMMONIAS COMPARED.—NOV. 12, 1898.

COTTON SEED MEAL.

Plot	1	2	3	4	5	6
1				*		
2					*	
3					*	
4				*		
5					*	
6					*	
7				*		
8		*				
9					*	
10					*	
11		*				
12				*		
13	*					
14	*					
15					*	
16			*			
17					*	
18					*	
40			*			
44	*					

SULPHATE AMMONIA.

Plot	1	2	3	4	5	6
19						*
20						*
21				*		
22		*				
‡23						*
‡24			*			
‡25					*	

SUL. AMMONIA CONT'D.

	1	2	3	4	5	6
26					*	
42			*			
46					*	
48	*					
49			*			
50		*				
51			*			

NITRATE OF SODA.

Plot	1	2	3	4	5	6
27	*					
28	*					
29					*	
30			*			
‡31		*				
‡32				*		
‡33				*		
41						*
45						*

BLOOD AND BONE.

Plot	1	2	3	4	5	6
34	*					
35	*					
36	*					
37		*				
‡38		*				
‡39	*					
43			*			
47				*		

§See illustration on previous page. Photographed November, 1898.

TABLE SHOWING RELATIVE LEAF AREA.—POTASHES COMPARED.—NOV. 12, 1898.

KAINIT.

Plot	1	2	3	4	5	6
10					*	
11		*				
12				*		
‡24			*			
‡25					*	
‡32				*		
37		*				
41						*
45						*

SUL. POTASH, L. G.

Plot	1	2	3	4	5	6
2					*	
3					*	
5					*	
‡31		*				
36	*					
50		*				
51			*			

SUL. POTASH, H. G.

Plot	1	2	3	4	5	6
16			*			
17					*	
18					*	
20						*
21				*		
28	*					
29					*	
35	*					

SUL. POTASH, H. G., CONT'D.

Plot	1	2	3	4	5	6
40			*			
42			*			
44	*					
46					*	
49			*			

MURIATE OF POTASH.

Plot	1	2	3	4	5	6
7				*		
8		*				
9					*	
22		*				
‡23						*
30			*			
‡38		*				

POT.-MAG. CARBONATE.

Plot	1	2	3	4	5	6
13	*					
14	*					
15					*	
26					*	
‡33				*		
‡39	*					
43			*			
47				*		
48	*					

§See illustration on previous page. Photographed November, 1898.

TABLE SHOWING RELATIVE LEAF AREA.—PHOSPHORIC ACIDS COMPARED.—NOV. 12, 1898.

BONE MEAL.

Plot	1	2	3	4	5	6
3					*	
4				*		
8		*				
11		*				
14	*					
17					*	
21				*		
22		*				
‡24			*			
48	*					
50		*				

BLOOD AND BONE.

Plot	1	2	3	4	5	6
34	*					
35	*					
36	*					
37		*				
‡38		*				
‡39	*					
43			*			
47				*		

ACID PHOSPHATE.

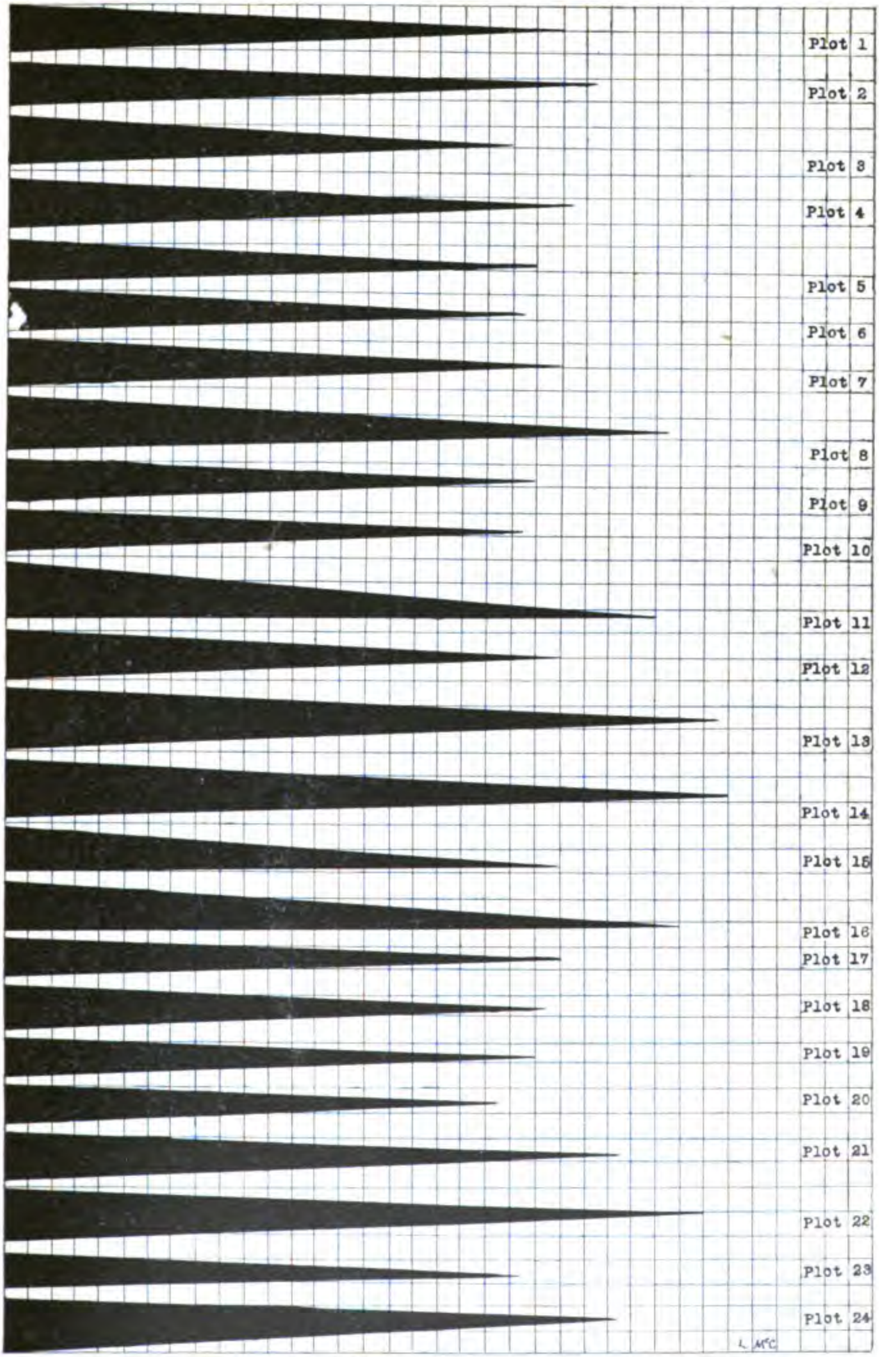
Plot	1	2	3	4	5	6
5					*	
6					*	
9					*	
12				*		
15					*	

ACID PHOSPHATE CONT'D.

Plot	1	2	3	4	5	6
18					*	
‡23						*
‡25					*	
26					*	
29					*	
30			*			
‡31		*				
‡32				*		
‡33				*		
40			*			
41						*
42			*			
43			*			
44	*					
45						*
46					*	
47				*		
49			*			
51			*			

‡See illustration on previous page. Photographed November, 1898.

PLATE I.



Diagrams to Illustrate Size and Shape of Average Leaf.

The foregoing diagrams illustrate the relative amount of leaf area. The width of each triangle represents the width of the leaves, and the length of each triangle the length of the leaves of the plot corresponding to the number given. The space between two lines represents one inch in length and each square a square inch. By looking over the various plots it will be noticed that there is decided variation in the width of the leaves. Plot 45 had the narrowest leaves, being only one and three-eighths inches wide, though not the shortest leaves. Plots 17, 20, 32 (see fig. 6) and 41 come next in order with leaves an average of one and five-eighths inches broad at the base. Plot 36 had the broadest leaves, being two and five-eighths inches broad at the base. Plots 35 (see plate 6), 39 (see fig. 1) and 48 had leaves with an average width of two and three-eighths inches at the base. There is also a very considerable variation in the length of the leaves, this, however, not being coincident with the width of the leaves. Plot 41 had the shortest leaves, but not the narrowest. Plot 20 had leaves whose average length was twenty and one-half inches, just a little longer than plot 41. Plot 28 (see right half of plate 5) had the longest leaves, averaging thirty-three inches. Plot 27 had plants with leaves thirty-one and one-fourth inches long. In plot 25 (see fig. 7) the leaves of the plants had an average length of 31 inches. In plots 14 and 50 (see left half plate 8) the plants had leaves with an average length of 30 inches. In plot 34 the average length of the leaves is 32 inches. By looking over the diagram it will be noticed that the widest leaves are not the longest leaves. In plot 34 the leaves had an average surface of 40 square inches, yet the leaves were neither the widest nor the longest leaves, being 32 inches long and two and one-half inches wide.

On the other hand the shortest leaves are not the narrowest leaves, as we will notice by comparing leaves in the table. We will, however, notice in the table that the five best plots—numbers 35 (see plate 6), 36, 37, 38 (see plate 8), and 39 (see fig. 1), have a very large comparative leaf surface. However, plot number 34, which was fertilized with blood and bone only had the largest leaf surface (Nov. 8, 1898,) in the field. What the yield in fruit would have been had no freeze occurred can be approximated more or less closely by the number of blooms which did occur. By referring to the notes we find that only two per cent. of the plants were in bloom at the time of the freeze. Yet while this plot had the largest leaf area in the field it produced a small amount of fruit and was very seriously injured by the freeze. Plot number 14 came second in size in regard to leaf area, showed very little fruit, matured less than one per cent., and stood the freeze remarkably well. Plot 27 was next in order of leaf area, showed twenty per cent. of plants in bloom at the time of the freeze and matured less than one per cent. of very small apples. (It will be remembered that this plot was fertilized with nitrate of soda only.) It suffered excessive injury from the freeze, which reduced the leaves almost to zero, but rapidly recuperated during the spring. Plot 28 (see right half of plate 5), came next in size of leaf area, showed twenty per cent. of fruit, being very much larger than those matured in 27. The frost resistance of this plot was strikingly better than that of 27.

QUANTITY OF FERTILIZERS AND FREEZE RESISTANCE.

It will be remembered from previous statement that all sections A received the normal amount of the normal fomula of fertilizer. That all sections B received twice the normal amount of ammonia and the normal amount of potash and phosphoric acid. That all sections C received the normal amount of ammonia, twice the normal amount of potash, and the normal amount of phosphoric acid. That all sections D were fertilized with the normal formula, but received 50 per cent. more fertilizer than sections A. That all sections F received 100 per cent. more of the normal formula of fertilizer than sections A.

As soon after the freeze as conditions would permit inspection to be made, notes were taken upon the effect of the freeze on different sections, as well as upon the different plots of the field. Plots 3, 5, 8, 11, 14, 31 (see fig. 3), 49 (see right half of plate 8), and 51 showed some variation in the different sections of the same plots in freeze resistant qualities. Plots 12 (see right half of plate 3), 15, 17, 18, 21, 22 (see right half plate 4), 23 (see left half plate 4), 24 (see fig. 4), 25 (see fig. 7), 26, 29 (see left half plate 5), 30, 32, 33, 34, 35 (see plate 6), 36; 37; 38 (see fig. 2 and plate 7); 39 (see fig. 1) and 50 (see left half plate 8), showed no variation of the effect of the freeze in different sections of the same plot. The rmaining plots had been fertilized with incomplete fertilizer formulae, or were not sub-divided into sections. Consequently these could not come into the present consideration.

In plot 3, section D was injured least. Sections A, B and C were injured more than D. Sections F more than A, B and C. Section E was injured most.

In plot 5 section F was injured most, E least and the remaining four sections about equally, and more than E and less than F.

In plot 8 section A was injured least, B stood next, C and F next, and B and E were injured most.

In plot 9 sections C and D were injured least and about equally. Sections B and E were equally injured, but less so than A. Section F was injured most in the plot.

In plot 11 section F was injured least, E stood next and the rest were about equally injured and more so than E.

In plot 14 section F was injured least, sections E and C stood next, and sections A, B and D were about equally injured and worst.

In plot 31 section A was injured least, B, C and D were about equally injured and stood next to A. Sections E and F were about equally and most severely injured.

In plot 49 (see plate 8, right half,) section D was injured least, the other sections being injured about equally and more than D.

In plot 51 sections E and F were injured least and about equally, the remaining four being injured more and about equally.

TABLE SHOWING EFFECT OF FREEZE WHEN AFFECTING SECTIONS DIFFERENTLY.

PLOT.	SECTION A.	SECTION B.	SECTION C.	SECTION D.	SECTION E.	SECTION F.
3	2[‡]	2	2	1	4	3
5	2	2	2	2	1	3
8	1	2	3	4	4	3
9	3	2	1	1	2	4
11	3	3	3	3	2	1
14	3	3	2	3	2	1
31	1	2	2	2	3	3
49	2	2	2	1	2	2
51	2	2	2	2	1	1
	19	20	19	19	21	21

DEDUCTION.

Reducing the whole matter to a table, we can make the following interesting deductions: When there was any difference in the sections of a plot A, C and D stood the freeze best on an average. Section B stood the freeze next to A, C and D. Sections E and F were most frequently injured most severely. Sections B were severely injured on the average. By further generalizing upon this we may see that the normal formula, or an abundant supply of potash and phosphoric acid caused the plants to be somewhat frost resistant. The extra supply of ammonia caused the plants to be sensitive to frost. An abundant supply of the normal formula caused the plants to be more sensitive to frost. Sections F, though having just as much ammonia as sections B, were on an average less frost resistant than sections B. This is probably due to their having an additional amount of potash and phosphoric acid, though sections F were not on an average as frost resistant as sections C and D, nor can we ascribe this peculiarity to the plants in these sections, being of a more succulent growth, as this does not seem to be borne out by the notes. At least that was the condition of the growth it was not apparent. It is also interesting in this connection to notice that plots fertilized with acid phosphate are no more nor less frost resistant than those fertilized with bone meal.

[‡] These figures refer to relative standing of the sections in the plot, 1 resisting freeze best, and 6 least. Where the same number occurs twice no difference was noticed between the sections having the same figures. The figures of different plots bear no relation to one another. For example, section A of plot 9 may have been more severely or less severely frozen than section A of plot 11.

QUALITY OF FERTILIZER AND FREEZE RESISTANCE.

COMPLETE FORMULAE.

Turning our attention now to the plots which showed no variation of sensitiveness to frost in the various sections we find a much more interesting variation in the frost resistants of the several plots due to a difference in source of the fertilizer.

AMMONIAS.

Comparing the different forms of ammonia we find those plots that are fertilized with nitrate of soda very sensitive to frost, those fertilized with sulphate of ammonia stand next in the scale, those fertilized with cotton seed meal coming third and those fertilized with blood and bone least sensitive. There being somewhat of a regular step between the four different forms, nitrate of soda standing at 5 points, sulphate of ammonia 4.20 points, cotton seed meal 3.55 points, blood and bone standing at 2.75 points. Zero representing plants not injured and six points representing plants frozen to the ground.

POTASHES.

By adopting the same standard for determining the relative position which the different forms of potash occupy we find that kainit stands at 4.77 points. Muriate follows this as a very close second with 4.14 points. Sulphate of potash, low grade, comes third in the list with 3.71 points. Sulphate of potash, high grade, stands fourth with 3.15 points. Potassium-magnesium carbonate coming in as most frost resistant with a very wide gap in its favor, standing at 2.77 points.

ACID PHOSPHATE AND BONE MEAL.

So far as these experiments go bone meal seems to have no advantage in producing freeze resistant plants over acid phosphate. This is quite remarkable in view of the fact that bone meal produces so much more leaf surface than acid phosphate.

INCOMPLETE FORMULAE.

Those plots fertilized with incomplete fertilizers in which potash was wanting stood at 4 points. Those plots in which phosphoric acid was wanting stood at 3.9 points. Those fertilized with ammonia alone stood at 4.23 points. The number of incomplete plots and the arrangement of them make these results less striking than they would probably be if this portion of the experiment had been carried out with greater detail, but the matter of the freeze in connection with these experiments was altogether incidental, and not a part of the plan.

CONCLUSION.

In brief it may be said that plots treated with a fertilizer whose ammonia has been derived from blood and bone are more frost resistant than plots fertilized with ammonia derived from cotton seed meal, sulphate of ammona, or nitrate of soda. That plots upon which potassium-magnesium carbonate has been used as a source of potash are more frost resistant than where kainit, muriate of potash, sulphate of potash, low grade, sulphate of potash, high grade, has been used. That on a whole plots fertilized with incomplete fertilizers, i. e., one in which one or two of the three essential elements are wanting, are less frost resistant than the average of those that have been fertilized with a complete fertilizer. An excess of ammonia over the normal formula appears to make the plants less frost resistant. An excess of potash or phosphoric acid does not seem to increase the frost resistant qualities over the normal formula.

TABLE ILLUSTRATING FERTILIZERS AND FREEZE RESISTANCE. AMMONIAS COMPARED.—FEB. 18, 1899.

COTTON SEED MEAL.

Plot	1	2	3	4	5	6
1				*		
2			*			
3			*			
4			*			
5			*			
6			*			
7			*			
8			*			
9			*			
10					*	
11					*	
†12			*			
†13		*				
14		*				
15				*		
16				*		
17				*		
18				*		
40					*	
44					*	

SULPHATE AMMONIA.

Plot	1	2	3	4	5	6
19					*	
20					*	
21					*	
†22			*			
‡†23				*		
‡24					*	
‡25			*			

SULPHATE AMMONIA CON'TD.

	1	2	3	4	5	6
26		*				
42			*			
46					*	
48					*	
†49		*				
†50					*	
51					*	

NITRATE SODA.

Plot	1	2	3	4	5	6
27						*
†28					*	
†29			*			
30				*		
‡31						*
‡32						*
‡33					*	
41					*	
45					*	

BLOOD AND BONE.

Plot	1	2	3	4	5	6
34						*
†35	*					
36	*					
37					*	
†‡38				*		
‡39		*				
43		*				
47	*					

*For explanation see discussion of ammonias, page 73.

†Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

§Illustrated by a plate, see end of bulletin. These photographs were taken July, 1899.

TABLE ILLUSTRATING FERTILIZERS AND FREEZE RESISTANCE. POTASHES COMPARED.—FEB. 18, 1898.

KAINIT.

Plot	1	2	3	4	5	6
10					*	
11					*	
†12			*			
‡24					*	
‡25				*		
‡32						*
37					*	
41					*	
45					*	

SULPHATE POTASH, L. G.

Plot	1	2	3	4	5	6
2			*			
3			*			
5			*			
‡31						*
36	*					
†50					*	
51					*	

SULPHATE POTASH, H. G.

Plot	1	2	3	4	5	6
16				*		
17				*		
18				*		
20					*	
21					*	
†28					*	
†29			*			
†35	*					

SUL. POTASH, H. G. CONT'D.

Plot	1	2	3	4	5	6
40					*	
42			*			
44					*	
46					*	
†49		*				

MURIATE POTASH.

Plot	1	2	3	4	5	6
7			*			
8			*			
9			*			
†22				*		
†‡23				*		
30				*		
†‡38				*		

POT.-MAG. CARBONATE.

Plot	1	2	3	4	5	6
13		*				
14		*				
15				*		
26		*				
‡33					*	
‡39		*				
43		*				
47	*					
48					*	

*For explanation see discussion of ammonias, page 73.

‡Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

†Illustrated by a plate, see end of bulletin. These photographs were taken July, 1898.

TABLE ILLUSTRATING FERTILIZERS AND FREEZE RESISTANCE.—BONE MEAL AND ACID PHOSPHATE COMPARED.—FEBRUARY 18, 1899.

BONE MEAL.

Plot	1	2	3	4	5	6
3			*			
4				*		
8				*		
11					*	
14		*				
17				*		
21					*	
†22				*		
‡24					*	
48					*	
†50					*	

BLOOD AND BONE.

Plot	1	2	3	4	5	6
34						*
†35	*					
36	*					
37					*	
‡†38				*		
‡39		*				
43		*				
47	*					

ACID PHOSPHATE.

Plot	1	2	3	4	5	6
5			*			
6			*			
9			*			
†12			*			
15				*		
18				*		
†‡23				*		
‡25				*		
26		*				
†29			*			
30				*		
‡31						*
‡32						*
‡33					*	
40					*	
41					*	
42			*			
43		*				
44					*	
45					*	
46					*	
47	*					
†49		*				
51					*	

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*For explanation see discussion of ammonias, page 73.

‡Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

†Illustrated by a plate, see end of bulletin. These photographs were taken July, 1898.

LEAF AREA AND FREEZE RESISTANCE.

It is not an unusual belief among pineapple growers, and also among experimenters with fertilizers, that the production of leaf area and freeze resistance are coinicident, i. e., many people believe that certain pineapple fields escape being frosted because they contain a greater amount of foliage than neighboring fields which were more severely hurt. All other conditions being exactly the same it goes without saying that the field of pines with an abundant foliage is much more frost resistant than one with less amount of foliage. Also that the difference of a few rods in a field often makes a difference between that of plants being frosted and plants escaping. A very slight protection, as a tree or shrubbery or a wind break often has the same effect. Fortunately for our experiments none of these conditions came in to make any difference in the field, i. e., those plots which have been compared had an identical exposure without any difference in the way of frost protection of trees and the plots being very small, only a few square yards, puts it practically out of the question that there was any other disturbing agent than that of the fertilizers applied to the soil. This is further enforced by the fact that the freeze cut the plants exactly to the row. So that plants occupying a place only a few inches removed from the others showed a marked difference in their frost resistance. This was so noticeable that it could be seen from the car window while riding on a passing train. Photographs were taken with the hope that some difference could be detected in these, but unfortunately the proper kind of plates were not obtainable at the time. Later when the frozen leaves were broken down and showed a clear contrast between the frozen and the portions that were not frozen the time could not be spared to get these photographs.

By turning to the table on pages 65-7 which compares the leaf areas of different plots we find that plots 34, 27 and 28 are among those that have the greatest leaf area. Plot number 34 seems to stand first, and at the same time was probably hurt worse than any other plot in the field, unless possibly 27 was injured more. Yet plot 34 occupied a place in the immediate vicinity of plots only slightly injured, and nearly contiguous to plot 39 (see fig. 1), the plot injured least in the whole field by the freeze. Plots 27 and 28 were contiguous, and yet plot 27 was frozen almost to the ground, while plot 28 escaped with about 30 or 40 per cent. of the area of the leaves. We might compare plot 28 with plot 29, the former having an abundant leaf surface, the latter not more than about one-fourth of the area, yet 29 came through with a much less comparative loss of leaf surface than 28.

In view of last winter's experience we can hardly do otherwise than come to the conclusion that pineapple plants may be so fertilized as to cause them to be much more frost resistant than they are at present. When we remember that during the freeze of last winter plugs of ice formed in the bud of the plants we are really astonished that pineapples escaped total destruction.

In the following three tables a star in column 1 denotes that the plants escaped with a loss of less than 20 per cent. of its foliage. In column 2 denotes that 20-35 per cent. was lost. In column 3, 35-50 per cent. In column 4, 50-65 per cent. In column 5, 65-80 per cent. And in column 6, over 80 per cent.

Compare table on pages 65 to 67, illustrating fertilizer and freeze resistance and plates 1 and 2, showing diagrams of leaf area.

FERTILIZERS AS CONTROLLING EARLINESS.

On the foregoing pages we have been considering the effect of fertilizer in producing frost resistance in plants. It is likewise interesting to notice that some fertilzers under similar conditions seem to force plants into bloom earlier than others. Nitrate of soda seems to start the plants early and cause a large number of blooms to appear. In plot 28, 90 per cent. of the plants showed bloom at the time of the freeze, February 13, 1899, while less than 10 per cent. of the plants matured fruit. This 10 per cent. includes some of the fruit that was not frozen at that time. Taking into further consideration plots 35 (see plate 6), 36, 37, 38 (see plate 7), and 39 or the five plots belonging in first class, we find that these had many flower bud showing at the time of the freeze. Plot 35 showing 92 per cent. of the plants in bloom, while 15 per cent. of the plants matured fruit. Plot 36 showed 70 per cent. in bloom, while 10 per cent. matured fruit. Plot 37 showed 60 per cent. of the plants in bloom and 3 per cent. matured fruit. In plot 38, 90 per cent. of the plants showed bloom and 17 per cent. matured fruit. In plot 39, 50 per cent. of the plants showed bloom and 30 per cent. matured fruit. Plot 34, in which no potash was used, there was only 2 per cent. of blooms showing and the plot matured only 10 per cent. of the fruit. From the experiments at hand it would seem that among the potashes high grade sulphate of potash, induced the plants to bloom early. Next would come muriate of potash, then low grade sulphate of potash, kainit, and next potassium-magnesium carbonate would retard them most. Nitrate of soda and high grade sulphate of potash induced an early bloom, and one that was very sensitive to the frost; consequently few plants in plot 28 matured fruit. The following table shows the approximate size of the fruit and the amount produced bv each of the five first class plots, giving them by sections.

By studying the table page 81 one is surprised to find how uniformly sections A, B and C are superior to D and E. It seems to indicate that the limit of profitable fertilization has been reached in section A. But we must not generalize on this table since we do not know what would have been the results had no freeze occurred. We have no reason for supposing that the sections would have occupied the same relative positions had no freeze occurred. It is certain, however, that those buds that would have made the largest apples and the best-paying shipments were the ones that were frozen.

When the pineapples were packed it was found that there were 4 crates of 36s, 6 crates of 42s, 4 crates of 48s, and 2 crates of 54s, indicating that the estimate of the size of the pines which was made in the field was below the right figure.

TABLE OF FRUIT PICKED JUNE 29, 1899.

PLOT 35.

SECTION.	SIZE OF FRUIT. 30s	36s	42s	48s	54s	NO. FRUITS.
A		5	8	22	6	41
B		6	11	4	2	23
C		3	11	3	4	21
D				2		2
E				2		2
		14	30	29	12	89

PLOT 36.

SECTION.	30s	36s	42s	48s	54s	NO. FRUITS.
A		1		14		15
B	1	2	9	4		16
C		6	4	2		12
D		3		7		10
E		2	6			8
	1	14	19	27		61

PLOT 37.

SECTION.	30s	36s	42s	48s	54s	NO. FRUITS.
A		1	8	7		16
B					2	2
C				3	3	6
D			1	1		2
E					6	6
		1	9	11	11	32

PLOT 38.

SECTION.	SIZE OF FRUIT. 30s	36s	42s	48s	54s	NO. FRUITS.
A			21	9		30
B		4	4	3	4	15
C			9	20	4	33
D			6	5		11
E			2	4	7	13
		4	42	41	15	102

PLOT 39.

SECTION.	30s	36s	42s	48s	54s	NO. FRUITS.
A			27	8	12	37
B			13	25	13	51
C			23	7	8	38
D			10	11		21
E			10	11	6	27
			83	62	39	174

TABLE CLASSIFYING PLOTS AND GIVING FERTILIZERS— FIRST CLASS PLOTS.

SOURCES OF		SOURCES OF POTASH.					
Ammonia	Phos. Acid.	Kainit	Sul. Pot. low gr.	Sul. Pot high gr.	Muriate Potash.	Pot-Mg Carb.	No. Potash.
Blood and Bone.		Plot 37. poorest.	Plot 36 eql to 35	Plt 35 §† betr. 37	Plt 38 §‡ sec bst.	Plot 39 † best	
SECOND CLASS PLOTS.							
Nitrate Soda.	No.			Plot 28 §			
Do.	Acid Phos.	Plot 41 ‡ Lime.					
Blood and Bone.							Plot 34.
Blood and Bone.	Acid Phos.					Plot 43 ‡ Lime. ‡	
Do	Do.					Plot 47‡ Muck.	
Sulphate Ammonia.	Bone Meal.					Plot 48 ‡ Mk & L.	
Do.	Acid Phos.			Plot 42 ‡ Lime.			
Cotton Seed Meal.	Do.			Plot 40‡ Lime.			

‡The position these plots occupy cannot be credited to the presence of muck or lime. The amount of work done is not sufficient to make any generalization upon, but the indications are that both the lime and muck were slightly detrimental.

†Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

§Illustrated by plate, see end of Bulletin. These photographs were taken July, 1899.

THIRD CLASS PLOTS.

SOURCES OF		SOURCES OF POTASH.					
Ammonia.	Phos. Acid.	Kainit.	Sul Pot. low grd.	Sul Pot. high gr.	Muriate Potash.	Pot. Mg. Carb.	No Potash.
Cotton S. M.	Bone Meal.					Plot 12 ‡ §	
Do	Do.					Plot 14	
Sulphate Ammonia.	Do				Plot 22 §		
Do.	Do.		Plot 50				

FOURTH CLASS PLOTS.

Cotton S M.	No.						Plot 1
Do.	Bone Meal.				Plot 8.		
Do.	Do	Plot 11					
Sulphate Ammonia.	No.		Plot 20				
Nitrate Soda.	No.						Plot 27.

‡Received one application of bone meal November 4-12 by inadvertent laborer.

†Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

§Illustrated by a plate, see end of bulletin. These photographs were taken July, 1899.

FIFTH CLASS PLOTS.

SOURCES OF		SOURCES OF POTASH					
Ammonia.	Phos. Acid	Kainit.	Sul. Pot low grd.	Sul·Pot. high gr.	Muriate Potash.	Pot. Mg. Carb.	No Potash
Cotton Seed Meal.	No.		Plot 2.				
Do.	Bone Meal.		Plot 3.				
Do.	Do.						Plot 4.
Do.	No.				Plot 7		
Do.	No.	Plot 10.					
Do.	No.			Plot 16.			
Do.	Acid Phos·			Plot 44. Muck‡			
Sulphate Ammonia.	No.						Plot 19.
Do.	Bone Meal.			Plot 21.			
Do.	Do.	Plot 24 †					
Do.	Acid Phos					Plot 26.	
Do·	Do.			Plot 49 §			
Do.	Do.		Plot 51.				
Nitrate Soda	Do.		Plot 31 †				
Do.	Do.					Plot 33 †	

‡See first foot note, page 82.

†Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

§Illustrated by a plate, see end of bulletin. These photographs were taken July, 1899.

SIXTH CLASS PLOTS.

SOURCES OF		SOURCES OF POTASH.					
Ammonia.	Phos. Acid.	Kainit	Suphate Potash. low grd.	Suphate Potash high gr.	Muriate Potash.	Pot-Mg. Carb.	No Potash.
Cotton S. M.	Acid Phos.		Plot 5.				
Do.	Do.						Plot 6
Do.	Do				Plot 9		
Do.	Do.	Plot 12§					
Do.	Do					Plot 15	
Do.	Do.			Plot 18			
Do.	Bone Meal.			Plot 17			
Sulphate Ammonia	Acid Phos,				Plot 23 † §		
Do.	Do.	Plot 25 ‡					
Do.	Do.			Plot 46 Muck †			
Nitrate Soda.	Do.			Plot 29 §			
Do.	Do.				Plot 30		
Do	Do.	Plot 32 †					
Do.	Do.	Plot 45 Muck ‡					

‡See first foot note, page 82.

†Illustrated by a figure, see previous pages. These photographs were taken November, 1898.

§Illustrated by a plate, see end of bulletin. These photographs were taken July, 1899.

SOME REMARKS ON THE NOTES TAKEN JUNE 28 AND 29, 1899.

Plot 3.—Taking this plot as a whole it would be put in the fifth class. See table. There is some variation in the sections which is interesting to note. Section E stood first, distinctly so. Section B second, section A third, section D fourth, section C fifth and section F sixth. This indicates pretty clearly that the normal formula when these substances are applied is about correct. Also that the amount applied to section E or 150 per cent. of the normal application is the amount which the plants can appropriate to the best advantage. Two hundred per cent. of the normal amount proved too much for the plants, and in the place of doing them an additional benefit it proved detrimental.

Plot 6.—The only points of interest here is that the substitute for acid phosphate in bone meal in plot 3 reduced the plot to the sixth class.

Plot 8.—In this plot section A stood first, B second, C third, D fourth, E sixth and F fifth. The plot was fairly uniform so that no very strict deductions can be made from it. It is probable, however, that in section A the normal amount was all that the plants could use. It is possible, of course, that this was even more than enough. It is interesting to note that section C which had a double supply of muriate of potash, showed no marked bad effect.

Plot 9 belonged to the sixth class. Probably every section in this plot was so bad that none could be really worse.

Plot 11.—This plot belonged to the fourth class, only section B going at a little higher rate or about third class. Section B stood first, section E second, section A third, section C fourth, section D fifth and section F sixth. The choice between D and E was not decided. This plot is interesting from the fact that the normal formula did not seem to be the best. That is the pineapples could make use of more ammonia than occurred in the normal formula. Hence section B came out best, and when the additional amount of potash, this being in the form of kainit, was added, it reduced the section immediately to a lower grade. The additional amount of phosphoric acid still further lowered the grade, so as to reduce this section F to the poorest in the plot.

Plot 12 (see right half of plate 3), in which occurred kainit and acid phosphate; there was no choice, all being equally poor.

Plot 12 (see left half of plate 3), was treated to an incomplete fertilizer, one wanting in phosphoric acid. By referring to plate 3 we see that there is quite an advantage in a change of potash and a rejection of the acid phosphate with which plot 11 was fertilized.

Plot 14.—In this plot the sections were not so variable as in some of those we have just studied. Sections A, C and D were about equally good and best. Section B was just slightly poorer. Section E stood about third and section F fourth, or poorest. From this we may learn that the normal amount of the normal formula was better in this particular case than in an increase of of the quantity of any of the fertilizers. While sections C and D were equal to A no advantage could be seen, excepting that C and D bore some fruit, while the other sections did not. The fact that section E was poor and section F poorest shows that we have at least reached teh limit of the amount of fertilizer that the plants could use in sections A, C and D.

Plot 15.—All sections equally poor and sixth class.

Plot 17.—All sections equally poor and sixth class.

Plot 19, fertilized with sulphate of ammona, only, fifth class.

Plot 20, fertilized with sulphate of ammonia and sulphate of potash, high grade, fourth class, showing that potash in addition to the ammonia was an advantage.

Plot 21, as a whole, belonged to the fifth class. Section A stands slightly best in the plot, indicating that the amount of this formula of fertlizer that the plants can use was either the amount applied to section A or something less.

Plot 22 (see right half of plate 4).—This plot, as a whole, is rated as third class. Section B stood first, F second, A third, D fourth, E fifth and C sixth. Section B was decidedly the best section in the plot, indicating that from this source the amount of ammonia used in section A was not as much as the plants could use. Section C fell to sixth class, probably because muriate of potash in this combination is a bad fertilizer. The fact that section E stood fifth and section F second is hard to account for. In section D ammonia was derived from bone meal (see formula, page 46), but not as much was used as in section B.

Plot 23 (see left half of plate 4 and fig. 8) was sixth class and uniformly bad.

Plot 24 (see fig. 4.)—Section E stood first, D second, F third, A fourth, C fifth, B sixth. Under these particular conditions the plot indicates that the plants could make use of more fertilizer from this source than would be given by the normal amount of the normal formula. That section D stood second shows that in this connection the ammonia from bone meal could be utilized to better advantage than sulphate of ammonia. Otherwise section B would have stood higher.

Plot 25 (see figure 7) was sixth rate, and uniformly bad.

Plot 26 was fifth rate with no section showing any advantage over another.

Plot 29 (see left half of plate 5) was a sixth rate plot. Section E stood first, section F standing second and A, B, C and D all about equally poor. The fact that section D was not perceptibly worse than section A rather discourages the idea that acid phosphate is detrimental because it contains some free sulphuric acid. And the fact that E and F are both better than sections B, C or D indicates further that the condition of the plants was not brought about by an excessive quantity of fertilizer. We can scarcely come to any other conclusion than that the combinascarcely escape from the belief other than that of the combination of nitrate of soda and sulphate of potash either high grade or low grade and acid phosphate is a bad combination for pineapple fertilizer.

Plot 30.—In plot 30 sections C, D, E and F were all equally bad, and poorer than A, B being the best section in the plot.

Plot 31 (see figure 3.)—Section A stood first, B second, C third, D, E and F equal, but worse than C. In this plot we have nitrate of soda, sulphate of potash, low grade, and acid phosphate. While the combination is a bad fertilizer it is not quite so bad as when high grade sulphate of potash is used.

The fact that section A is best indicates that the remaining sections have received so much fertilizer as to prove injurious to them.

Plot 32 (see figure 6.)—Section D stood first, A second, C third, B, E and F were about equal and stood fourth. Here again we have evidence that the detrimental quantities of acid phosphate are not due to some caustic property within it. Otherwise section D would have been poorer than section A. We must simply put it down as a fact that this combination of ingredients makes a bad fertilizer.

Plot 33 (see figure 5) is not of any particular interest, the sections coming out almost like those of 32. The plot, as a whole, being one grade better.

Plot 34 is interesting from the fact that it was fertilized with blood and bone. Until November, 1898, this plot seemed to do as well as other plots fertilized with blood and bone to which had been added potash. This is quite interesting from the fact that up to this time there seemed to be a sufficient amount of potash in the soil, or otherwise available to carry the plant along without any perceptible disadvantage, but it showed a decided disadvantage in passing the cold weather, for by the time the freeze occurred there was a perceptible falling off in the size of the leaves. The freeze wrought great injury from which the plot has not been able to recover. It seems quite evident that it is merely a question of time until this plot must be abandoned.

In the matter of taste the pineapples from this plot were flat and insipid, being neither sweet nor having any edge to them. This plot was decided in three sections—A, B and C. A received the normal amount of ammonia, B 150 per cent. the normal amount of ammonia, C 200 per cent., the most normal amount, while plot C matured the greatest number of apples, otherwise there was no perceptible advantage. At the time of the freeze only 2 per cent. of the plants were in bloom, and only 13 per cent. of the plants matured fruit. Supposing that all of the blooms which showed at the time of the freeze were killed we would find that blood and bone used alone as a fertilizer would give us only 15 per cent. of fruiting plants for the first crop.

Plot 35 (see plate 6.)—Of this we can say very little except that all sections appeared to be about equally good. By referring to the table on page 81 it will be seen that the greatest amount of fruit occurred in section A. The next in sections B, C and E being decidedly low in the amount of fruit. By referring to the table it will be seen that there was about 90 per cent. of the plants showing fruit at the time of the freeze. Many of these fruits must have escaped the freeze from the fact that over 10 per cent. of the plants matured fruit. The fact that sections D and E matured so little fruit is at least partially accounted for from the fact that these were slightly more advanced than in the other sections. The main reason, however, is that the limit of fertilization had been reached in section A, since an additional amount of blood and bone or of sulphate of potash, high grade, gave a slight diminution in the leaf area and of fruit.

Plot 36.—This plot was remarkably even, all the sections being equally good. If any difference existed it might possibly be in section E, being slightly poorer than the others. From this plot we learn that the amount of blood and bone and sulphate of potash, low grade, used on section A was better than in a larger amount of either blood and bone and potash, or both together. By referring to the table on page 81 we will see that the amount of fruit produced in the various sections was quite even excepting in E which fell slightly below the rest.

Plot 37.—This plot was also very even excepting that section E fell below the rest. The plot, as a whole, however, was not so good as plot 36. By referring to the table on page 81 we will see that the amount of fertilizer used in section A was better than any succeeding ones. By referring to the table on page 82 we will see that this plot is listed as the poorest of the first class. The amount of buds showing at the time of the freeze was about 60 per cent., the amount of fruit maturing about 10 per cent. Nearly all of the leaves were frozen down to about one-fourth of their length.

Plot 38 (see plate 7 and figure 2.)—This plot seemed to be very uniform throughout, there being very little difference, unless section E was slightly below the rest. In the matter of fruit buds there were about 90 per cent. showing at the time of the freeze, while about 16 per cent. of the plants matured fruit showing that some of the fruit buds which were showing at the time of the freeze possibly passed without being destroyed. At least 25 per cent. of the plants escaped with one or more of their exposed leaves not frozen.

Plot 39 (see figure 1.)—In most respects this plot is the best in the field. The sections were unusually even. Scarcely any perceptible difference exists. From this we may infer that the amount of fertilizer used on section A was sufficient, and that while using more fertilizer did not prove disadvantageous to the crop it was just that much material added more than necessary. By referring to the table on page —— we notice that only about 50 per cent. of the plants were in bloom at the time of the freeze. A number of these escaped. About 30 per cent. matured fruit, making a showing of about 80 per cent. of the plants to produce fruit for the first crop—not so good a showing as in plots 35, 36 and 38. In the matter of taste the fruit was fully equal to 35 and 36, also in general appearance and shipping qualities. This was the most frost resistant plot in the whole field, showing its advantage to the row, while the leaf area was not quite up to 35 and 36. While in most respects this plot was the best in the field, it was exceeded by plots 35, 36 and 38 in the number of plants that would have produced fruit the first year in the normal conditions. Another disadvantage is that the plants are somewhat yellowish, exhibiting none of the deep blue green manifested by plants in plots 35, 36 and 38. Plots 40, 41, 42, 43 and 48 were treated with air slaked lime at the time of the first application, February 7 and 8, 1898. As these plots showed no advantage from the application of lime they are of no special importance. Plots 44, 45, 46, 47 and 48 were treated with air dried muck, but we find no special advantage from its application.

Plot 49(see right half plate 8.)—Section D stood first, C second, A third, B fourth, E fifth and F sixth. Section D coming first in this plot shows that the plants could make use of more acid phosphate than is given to them in section A. Also that section C gave better results than A and showed that more sulphate of potash, high grade, than was given to section A could be used by the plants. The fact that section B took fourth place indicates that the amount of sulphate of ammonia in combination with the other elements applied to this section was detrimental. This conclusion is further borne out by the results of sections E and F. The fact that section F is worse than either D, C or E forces us decidedly to the conclusion that this combination of fertilizers is not a good one, and that the limits of fertilization of this combination is somewhere below the amount applied to section A.

Plot 50 (see left half plate 8).—Section B stood first, C second, A third, D fourth, E fifth and F sixth. The fact that sections B stands first and that as a whole this section must be rated at about a second rate we must conclude that sulphate of ammonia in itself is not a bad form of ammonia for pineapples, but that there are combinations in which we cannot use it to advantage. Since section F stands lowest and E stands next the amount of this fomula used in section A is sufficient or more than sufficient. But since sections B and C are better than A we are inclined to believe that the normal formula for this combination is not the best one.

Plot 51.—Section 1 stands first, section E second, section B third, F fourth, and C and D about equally poor. The fact that section A is best indicates that the normal amount of the normal formula is the best that has been used in this plot. Since sections C and D are both poorer than E and F we must regard that sulphate of potash, low grade, and acid phosphate are the fertilizers in this combination that make it undesirable.

TABLE ILLUSTRATING NOTES TAKEN JUNE 28 AND 28, 1899.

PLOT.	SECTION A.	SECTION B.	SECTION C.	SECTION D.	SECTION E.	SECTION F.	PLOT.	SECTION A.	SECTION B.	SECTION C.	SECTION D.	SECTION E.	SECTION F.
3	3	2	5	4	1	6	†29	3	3	3	3	1	2
8	1	2	3	4	6	5	30	2	1	3	3	3	3
9	6	6	6	6	6	6	‡31	1	2	3	4	4	4
11	3	1	4	5	2	6	‡32	2	4	3	1	4	4
†12	6	6	6	6	6	6	†33	2	2	2	1	3	4
14	1	2	1	1	3	4	34	2				2	2
15	6	6	6	6	6	6	†35	1	1	1		1	1
17	6	6	6	6	6	6	36	1	1	1		1	1
21	5	5	5	5	5	5	37	1	1	1		1	1
†22	3	1	6	4	5	2	†‡38	1	1	1		1	1
†‡23	6	6	6	6	6	6	‡39	1	1	1		1	1
‡24	4	6	5	2	1	3	†49	3	4	2	1	5	6
‡25	6	6	6	6	6	6	†50	3	1	2	4	5	6
26	5	5	5	5	5	5	51						

ANALYSES OF PINEAPPLE.*

The following table shows the food constituents contained in pineapple. In this connection our main interest centres in the last named material, ash or mineral matters:

Water		89.3 per cent
Protein	0.4 per cent	
Fat	0.3 per cent	
Carbohydrates	9.7 per cent	
Total		10.4
Mineral matter (ash)		.3 per cent
		100.00

---

*Atwater and Wood's 4th Annual Report, Storr Agrl. Exp. Sta. 1891, page 87.

**Bowery, J. J., F. C. S., F. I. C., Island Chemist, Bul. Bot.

†Illustrated by a figure, see previous page. These photographs were taken November, 1898.

‡Illustrated by a plate, see end of bulletin. These photographs were taken July, 1899.

As above stated we will now look into the ash** constituent Dept., Jamaica, Vol. III, part 10. (Oct. 1896), page 236.

ASH OF PINEAPPLE.

Potash K^2O	49.42
Chloride of potassium KCl	.88
Chloride of sodium NaCl	17.01
Magnesia MgO	8.80
Lime CaO	12.15
Phosphoric acid P^2O^5	4.08
Sulphuric acid H^2SO	Trace
Silica SiO^2	4.02
Phosphate of peroxide of iron	2.93
	99.29

FRUIT, SOIL AND FERTILIZER.

Turning our attention to the chemical analysis of the pineapple we notice that nearly one-half of the ash constituent of it is potash (K^2O). Turning now to chemical analysis of the soil and remembering Hilgard's average, we see at once that our soil is exceedingly deficient in potash, the most abundant ash constituent in the pineapple.

Comparing the amount of soda contained in the pineapple with the amount present in the soil we are led to believe that this mineral constituent may be there in sufficient abundance. This belief is still further enforced by the fact that those fertilizers, excepting nitrate of soda, which contain a considerable quantity of soda were detrimental to the growth of the pineapple. Comparing the amount of magnesia in the soil with the amount required by the pineapple plant we are inclined to believe that this mineral constituent in the soil is somewhat low, and again the results of the experiments seem to support this conclusion from the fact that in a general way the double salts of potassium-magnesia carbonate and low grade sulphate of potash, gave slightly better plots than high grade sulphate of potash, which contained no magnesia. The carbonate of potash also contains carbonate of magnesia, but since the form of potash is slightly different from that in the case of the low grade sulphate of potash, the comparison is not so direct or striking. Lime is also one of the important constituents of the pineapple. We find some soils, however, that are entirely wanting in this important mineral, while others are abundantly supplied. By referring to our table on page 30 of the fertilizers used it will be noticed that low grade sulphate of potash, yields a considerable quantity of this mineral. There is also a considerable quantity of lime in potassium-magnesia carbonate, but the exact amount is not at hand. The other fertilizers, excepting acid phosphate, are quite deficient in this respect. In regard to the amount of phosphoric acid present in the pineapple we will notice that there is less than one-tenth as much by weight as potash. Referring to the table of the soil analysis we notice that the soils contain considerable quantity more of phosphoric acid than of potash, and since the pineapple requires less phosphoric acid we can see that it is not surprising that those plots in which phosphoric acid was wanting gave better results than those in which potash was wanting. The results of our experiments show that the normal formula contained more than enough phosphoric acid. By comparing the amount of iron (Ferric oxide) present in the soil we see that this mineral is comparatively abundant in Brevard county soils.

Looking at the matter from a chemical standpoint of view we are inclined to believe that low grade sulphate of potash or potassium-magnesium carbonate give us the best form of potash to apply to the particular class of soils, and since the experiments lead to the same conclusion the opinion seems to be pretty well founded.

A PLAN FOR FERTILIZING.

Having the foregoing experiments in mind, and considering the general conditions of the leading pineapple section, the following general plan for fertilizing pineapples on high spruce pine land may be recommended. If plants are set out during July or August, immediately after setting out drop into the bud a small handful of fertilizer. This should be composed of three parts of cotton seed meal and one part fine ground tobacco dust that has not been leached. This will keep the plants from being sanded (see appendix) and will give them some fertilizer to start them as soon as the soil is sufficiently moist. It will take about 300 pounds of cotton seed meal and

100 pounds of tobacco dust per acre. Double this quantity of fertilizer would probably be more beneficial.

As soon as the plants have taken a good hold in the soil, which will be during October or the early part of November, apply 680 pounds of blood and bone and 500 pounds of potassium-magnesium carbonate. If potassium-magnesium carbonate is not obtainable use about 400 pounds of low grade sulphate of potash instead.

During a favorable season this will cause the plants to increase rapidly in size. If, however, the season should be unfavorable and the plants do not succeed in making a good growth, the same formula may be applied about the middle of February, or when danger from frost is passed. If the plants have increased considerable in size and are making a good growth it is quite probable that they will be able to stand about 1,000 pounds of blood and bone and 750 pounds of potassium-magnesium carbonate, or 550 pounds of low grade sulphate of potash.

A third application of fertilizer may be given in the summer shortly before or at the beginning of the rainy season. The amount of fertilizer to be used at this time should be guaged very largely by the size of the pineapple plants, using from 1,000 to 2,000 pounds of blood and bone and from 750 to 1,500 pounds of potassium-magnesium carbonate, or 550 to 1,100 pounds of low grade sulphate of potash. The next application should be made in the fall during October or early November, so as to put the plants in excellent condition to stand the winter. A well fed horse and a well fed soldier will stand a campaign with much less danger of being sent to the hospital than a poorly fed horse or a poorly fed soldier. It is just the same with the pineapple plant. The winter time is its time of hard campaign, and a plant well fed on a balanced ration will stand the severest winters much better than one that has been under fed or fed with an improperly balanced ration. (See Fertilizer and Freeze Resistance.)

If at any time during the growing season the pineapple plants seem to come to a standstill, and fail to respond a light application of nitrate of soda will spur them up. In applying it care must be exercised that the substance does not get into the bud nor into the axiles of the leaves, as it is very caustic; 200 to 300 pounds of nitrate of soda per acre should be an abundance for a single application, but it is advisable to apply this separately from the other fertilizer and a month or so after a general application.

If blood and bone be too expensive one may substitute for it 2 pounds of dried blood and 4 pounds of bone meal for every 10 pounds of blood and bone.

If potassium-magnesium carbonate be difficult to obtain three-fourths of the amount of low grade sulphate of potash may be used in its place.

If the fertilizer is mixed at home, and for immediate use it may be advisable to substitute muriate of potash in the summer and fall application, reserving the potassium-magnesium carbonate or low grade sulphate of potash for the spring application. That is the muriate of potash should be used for making growth, and the carbonate or sulphate for finishing out the fruit. It is altogether probable that there would be no bad effect from applying these different forms of potash at different times, since no bad effects were noticeable when plots fertilized with these different forms of potash came in contact.

APPENDIX.

DISEASES.

SPIKE, LONG LEAF.

The term spike has been a common one among the pineapple growers for a number of years. Just how the term originated is hard to say, but it seems to be so expressive of the conditions in which pineapple plants are found that everybody seems to adopt it and uses it with evident satisfaction. Illustrations of this disease will be found by referring to plate representing plot 12 (see right half of plate 3), plot 23 (see left half of plate 4 and figure 8) and plot 29 (see left half of plate 5). By close observation it will be noticed that the plants have the leaves firmly contracted at the base, forming a more or less contracted top. The leaves then spread out, but stand alone in the air. Their color is a peculiar green. By referring to the notes taken during October, 1898, it is found that all of the plots fertilized with cotton seed meal, sulphate of ammonia, and part of those fertilized with nitrate of soda were affected with spike. In some cases as high as 90 per cent. showed this peculiar disease. Those plots fertilized with acid phosphate were affected more than those fertilized with bone meal. Those fertilized with kainit were worse than those treated with other forms of the potash. In plot 13 (see left half of plate 3) 8 per cent. were spiky. This plot was referred to especially because by July, 1899, the plants had almost entirely outgrown this condition. In plot 51, fertilized with sulphate of ammonia, sulphate of potash and acid phosphate, about 70 per cent. were spiky. Nitrate of soda in the absence of kainit, muriate of potash, acid phosphate, produced less spike than where acid phosphate, kainit or muriate of potash was used in conjunction with it. Plot 50 (see left half of plate 8), in which bone meal was used as a source of phosphoric acid in the place of acid phosphate, there was less than 10 per cent. spiky plants present.

In plot 15 the disease took the form of long leaf, though mixed with the long leaf was some spike. In plots 16, 17, 18, 19, 20, 21 and 22 (see right half of plate 4) the plants were affected from as low as 20 per cent. to up as high as 90 per cent. with long leaf.

From our experience with the fertilizers in these plots it comes out quite clearly that the disease known as spike or sometimes taking the form as what is known as long leaf is the result of improper fertilization. That while, as a whole, the plants are in decidedly poor condition for further growth proper fertilizer when taken in time can produce quite a remarkable change in the plants. Just whether this would be economical would have to be tested by the pineapple grower himself, and would depend so largely upon conditions that we are not ready to answer the question. It is a safe rule for a pineapple grower to discard all sickly plants and work only with the best of material. Cotton seed meal, sulphate of ammonia, kainit, muriate of potash and acid phosphate seem to be poorly adapted to bringing plants out of this condition and seem to be the fertilizers which are most liable to produce spike. The young field of plants which seem to have a tendency to spike would probably be benefited by withholding the original fertilizer and applying in its stead 400 pounds of nitrate of soda and about 800 pounds of low grade sulphate of potash per acre for one application. If the field needs phosphoric acid some other form than acid phosphate should be used. If dried blood or blood and bone be not too expensive this form of ammonia is advised for the following applications in the place of nitrate of soda. Bone meal could also be substituted, but this is usually too high priced to prove economical.

SANDING.

This term is frequently applied to plants which have been recently set and the winds and rains have filled the bud with sand. The effect of this is to strangle or choke the plants. Long continued wet weather, when the plants are in such condition, is liable to prove disastrous. There are several ways of preventing this trouble. By planting them so that the bud will not be low enough to permit sand to be blown or washed into it. If it is desirable to plant such small plants or plant them so deep as to endanger their being sanded, a mixture of three or four parts of cotton seed meal to one of tobacco dust may be dropped into the bud, dropping a small handful into each crown. This material forms a solid cake in the bud, and as the plant grows it forces the plug of cotton seed meal and tobacco dust upwards, thus giving ample opportunity for respiration and at the same time affords a very considerable amount of fertilizer for the plants at the time it is needed, and in the place it is needed. Blood and bone has also been used for this same purpose. Tankage may also be used.

Under pineapples sheds there is very little trouble from this source. There is very little trouble from this source if large, stalky plants are used.

RED SPIDER.

Stigmaeus sp.

This spider mite makes its home at the base of the leaves upon the tender white tissue. At this place the insect mite lives and lays its eggs, producing young in myriads, unless checked in some way. While the amount of damage done to the plant seems to be insignificant and the amount of material used by the red spider is not really worth consideration, it is the means of making an opening in the epidermis of the plant, affording an entrance for bacteria and fungi. So that while the red spider as a primary cause would hardly have attracted much attention, still as it so often results in the entire rotting off of leaves and finally the whole bud rotting out, the damage becomes quite serious at times, especially is this the case in the finer varieties of pines. Such hardy varieties as the red Spanish rarely suffer seriously. Young plants set out but a short time are damaged more than older ones.

The remedy for this disease is so simple and so generally known among pineapple growers that very little loss occurs from it excepting by inadvertance. This insect may be destroved by simplv placing a small quantity of strong tobacco dust into the bud of the plant. The dew and rain are caught by the leaves and conducted down into the bud, dissolving out the nicotine of the tobacco which is carried to the red spider and destroys it. One application is usually sufficient. However, if in the course of a week or ten days live red spiders are still to be found another application may be necessary.

It is largely for the red spider that the tobacco dust is mixed with the cotton seed meal mentioned under the discussion of sanding.

SCALE INSECT.

Diaspis bromeliae.

The scale insect of the pineapple rarely becomes important in the State, still may specimens have been sent to us at the College during the last year. Where this insect proves sufficiently abundant to require treatment a spraying of resin wash has been found to be entirely efficacious.

RESIN WASH.

Resin	20 pounds
Caustic soda (70 per cent. strength)	5 pounds
Fish oil	3 pints
Water to make	10 gallons

PREPARATION.

Place the resin, soda and fish oil in a large kettle, put in enough water to cover four or five inches deep; then boil for an hour and a half, when the liquid will be a dark coffee brown color. Pour into a half barrel and while hot add enough hot water (cold water will produce a flocculent precipitate) to make ten gallons. When cool mix thoroughly one gallon of the solution with nine of water and apply. Use rain water or soft water.

This insect occurs usually upon the green portion of the leaves more abundantly near the base of it than towards the tip.

MEALY BUG.

Dactylopius citri, etc.

From specimens received from various portions of the State together with the specimens of the mealy bug in the propagating house at the Experiment Station, it seems probable that there are two or more species of insects which attack the pineapple plants that are generally known as mealy bugs. Those attacking the pineapple plants at the Experiment Station have been identified as *Dactylopius citri*, or the same species which occurs upon the orange. Specimens sent in from South Florida appear to belong to some other species. While it is of great economic importance to know just what species may occur on pineapples, and exactly what species are in our plantation, for our present consideration, it will be sufficient to class them under the head of Mealy Bug.

This insect infests pineapple plants on the white portion of the leaves, about the body of the plants and on the larger roots. Occurring on this portion of the plant it may become quite severe in a plantation before it is discovered. Besides occurring at the base of the plant it also occurs on the flowering stock, especially under the scaley leaves of the fruit. If treated during the rainy season less trouble will be experienced than during another portion of the year. Ants make it their business to transport this mealy bug from one plant to another, disseminating them finally throughout the entire field. The treatment is to spray with the resin wash mentioned under the head of Scale Insects.

In buying plants it is a part of prudence not to accept those infested with any insects, particularly those infested with the mealy bug. To set out such plants is merely laying up trouble for a future day. Where plants are unusually valuable and scarce it may seem almost necessary to plant infested stock. In such cases all the outer leaves of the plants should be stripped off, and the plant thoroughly treated with the insecticide advised under Scale Insects before setting out and again after setting out.

BLIGHT ; WILTS.

These two terms are used indiscriminately for what appears to be the same disease. Prof. Webber has given this disease some attention and discovered a fungus in connection with the roots of the pineapple plant. He advises "digging up all blighted plants, pruning them thoroughly, removing the basal leaves and cutting off the end of the stem of all the roots which have started, as in case of preparing a sucker for planting and finally transplanting." While this disease is quite severe in some cases, and quite generally disseminated, it is not an easy matter to discover a preventive for it. Since its occurrence is not sufficiently uniform to enable one to predict where it will occur next or general enough to warrant a wholesale treatment. Queens and Porto Ricos seem to be more severely affected than Red Spanish and other varieties.

TANGLE-FOOT.

Tangle-foot, which is manifested by the roots winding firmly about the base of the pineapple plant, occurs frequently in fields. It has been observed more commonly on the long-leaf pine land than upon the spruce pine land. Whether there is any connection between the class of soil and the disease has not been established.

The cause, cure and preventive of this disease are not well understood.

REMARK.

As a general rule we may say that whenever pineapples are suffering from any disease it is cheaper for us to discard the whole lot and start in with healthy plants than to doctor up the sick ones. In most cases as much will be lost in fertilizers as would buy healthy plants, besides losing the valuable time and the use of the money invested. Of course from the standpoint of plant pathologists it is very important that he should know about the development of the disease and what to do to prevent it, but for the pineapple grower who is in it for the profits, it will be most economical in the end to use nothing but the best plants in the healthy condition.

USEFUL PUBLICATIONS IN STUDYING FERTILIZERS AND SOILS.

Voorhees, E. B.—Fertilizers, The Macmillan Company, New York, 1898.

King, F. H.—The Soil, Its Nature and Fundamental Principle of Management. The Macmillan Company, New York, 1895.

Semper, F. H.—Manures; How to Make and How to Use Them. W. Atlee Burpee & Co., 1893.

Superphosphates; Its Manufacture. Bulletin 10, pages 12, etc.

Soil and Fertilizers. Bulletin 20.

Fertilizers; How to Make and How to Use Them. Bulletin 22.

Pineapple—Notes on Experiments with The. Bulletin 27.

The Pineapple at Myres. Bulletin 37. (Includes construction of shed.)

A Chemical Study of Some Typical Soils of the Florida Peninsula. Bulletin 43.

Florida Agricultural Experiment Station.

Lake City, Fla., August 9, 1899.

EXPLANATION OF PLATES.

From Photographs taken July, 1899.

Plate 3.--Representing plot 13. The row in which the label occurs was fertilized on the right side by formula for plot 12, and on the left side by formula for plot 13. Beginning to count with the row occupied by the label and counting four rows to the left gives plot 13 (see page 43.) Beginning with one row to the right of that occupied by the label and counting four rows to the right we have section F of plot 12.

Plate 4.—The row in which occurs label number 23 is fertilized on the left side by formula for plot 23 (see page 47), and on the right side by formula for plot 22. Beginning with the row in which the label occurs and counting four rows to the left we have section A of plot 23. By following row number 2 of section A we may observe the label marking plot 16. Four rows to the left of this at the upper end may be seen label to plot 17.

Plate 5.—The row occupied by label number 29 was fertilized on the right side by fertilizer for plot 28 (see page 49). and on the left side by fertilizer for plot 29. By counting four rows to the left, beginning with the one occupied by the label we have section A of plot 29. The fifth row beginning with that occupied by the label is the first row of section B of plot 29. About one-half inch from the left margin of the plate may be observed the label belonging to plot 24 (see figure 4.)

Plate 6 represents section A of plot No. 35.

Plate 7 represents section A of plot No. 38.

Plate 8.—The row occupied by label was fertilized on the right side by formula for plot 49 (see page 55), and on the left side by formula for plot No. 50. Beginning with the row occupied by the label and counting four rows to the left we have section A of plot No. 51, and to the right side counting four rows we have section F of plot No. 49. It will be noticed that section E of plot 49 is superior to section F.

PLATE III.

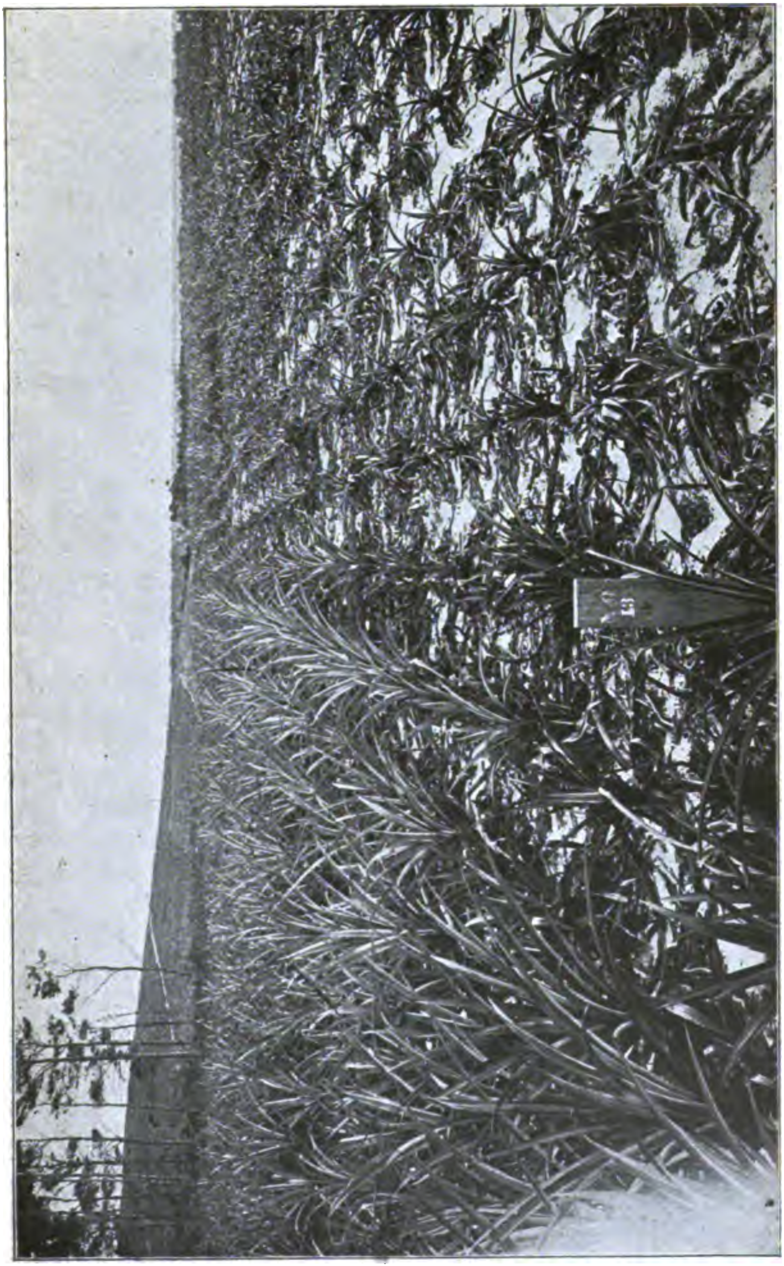

PLATE IV.

PLATE V.

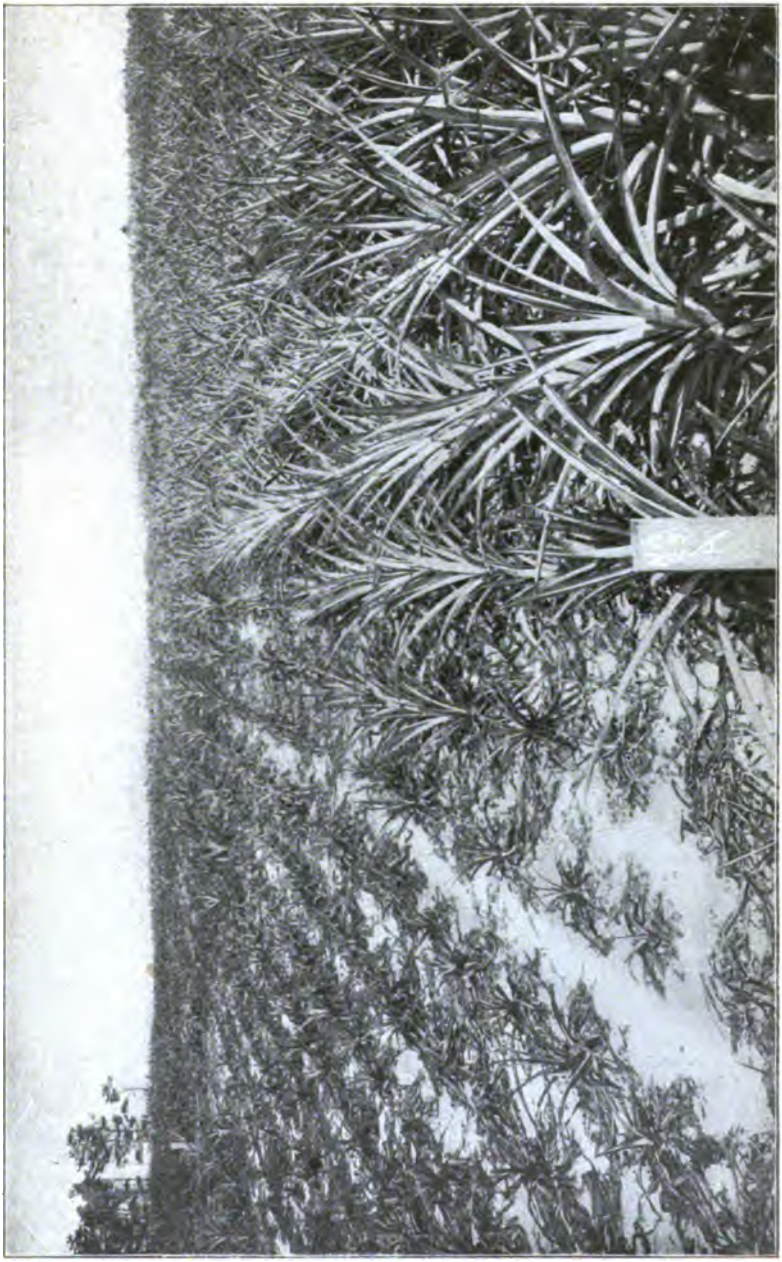

PLATE VI.

PLATE VII.

PLATE VIII.

BULLETIN NO. 51. JANUARY, 1900.

FLORIDA
Agricultural Experiment
STATION.

Some Common Florida Scales.

—BY—

H. A. GOSSARD.

The Bulletins of this Station will be sent Free to any
Address in Florida upon Application to the Director
of the Experiment Station, Lake City, Florida.

JACKSONVILLE, FLA.
THE H. & W. B. DREW COMPANY,
1900.

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SOME COMMON FLORIDA SCALES.

By H. A. Gossard.

The frequency with which specimens of the following scales are received at the Experiment Station, with inquiries regarding their life histories and remedial measures against them, furnishes the occasion for this brief bulletin. While the principal plants upon which they have been reported, namely, citrus and pineapples, occupy but a comparatively small acreage in Florida at present, the many difficulties attending their successful production apparently stimulates careful observation on the part of the producers, and we, therefore, have had a greater number of queries relating to these scales than to any other insects in the State.

The observations set forth are, for the most part, given upon the authority of others, particularly of Hubbard and Comstock, the particular excuse for publishing what only pretends to be, in a large measure, a review of their writings being found in the fact that their papers are not accessible to the Florida growers.

However, the writer is alone responsible for the economic observations, and for the statement of facts not found elsewhere. The lists of food plants given in Coccidæ Amercanæ, prepared by Professors Rolfs and Quaintance, have been consulted, but their complete lists have not been given in every case.

THE PURPLE SCALE, *Mytilaspis citricola* (Packard).

This is one of the commonest and most conspicuous citrus scales in Florida. The insect seems to be widely known wherever the orange is grown, either in this country or abroad. Hubbard observed in 1885 that it was more abundant in the northern than in the southern portions of the orange belt. The freezes since that time seem to have reversed this order of distribution; this season's observations have not discovered it in any of the northern nurseries, nor in the more northern groves.

The scale of this species is one of the largest in the genus. The scale of mature females sometimes reaches a length of 0.12 of an inch (2 mm.), and that of the male 0.05 of an inch (1.4 mm.). The name, "Oyster Shell Bark-louse," has been applied to one member of the genus, *Mytilapsis pomorum*, a common apple pest, because the general outline of the scale, together with its ridgings and markings, are so suggestive of an oyster shell in miniature; the purple scale,

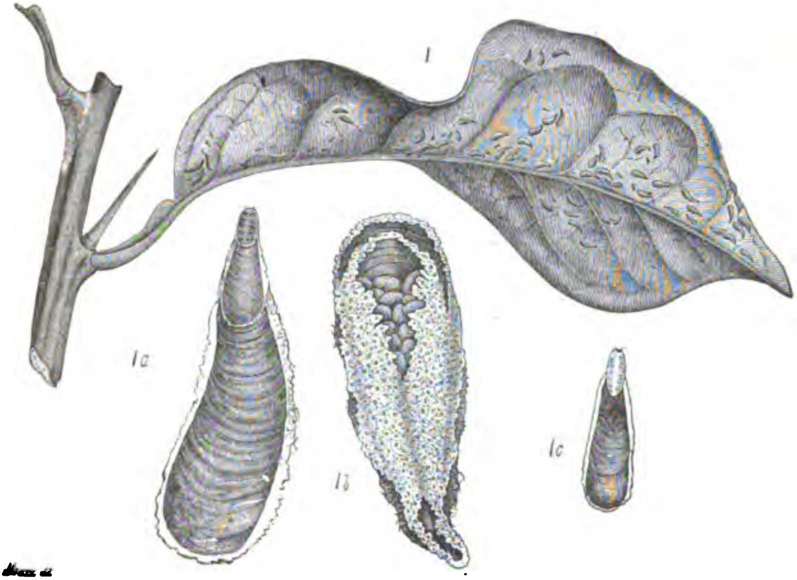


Fig. 1.

Mytilaspis citricola (Comstock, Div. of Entomology, U. S. Dept. of Agr., Ann. Report, 1880).—1. Scales on orange, natural size; 1*a*, scale of female, dorsal view, enlarged; 1*b*, scale of female with ventral scale and eggs, enlarged; 1*c*, scale of male enlarged.

Mytilaspis citricola, and in lesser degree, the long scale, *Mytilaspis gloverii*, share this resemblance, and so it is not uncommon to hear the term, "Oyster Shell Bark-louse," applied to any one of them by the general public. The form may be described as broadly trumpet-shaped, increasing in width behind, often curved like an oyster shell, but rarely or never with the sides parallel. The surface is glossy and smooth and from a light to a dark red-brown purple color. The male scales being less than half the length of the females, of a more linear shape and straight outline, may suggest some other species of insect upon superficial examination, but its identity cannot be confused with any other species than the long scale, *Mytilaspis gloverii*, the female of which is twice as long as the male *citricola*, and the male of which is shorter and rather more slender, both absolutely and relatively. The characteristic purple color which the males give to a mass of scales belongs to no other species of Mytilaspis.

The eggs are pearly white, very minute, elongate oval, and are usually laid in four rows, but sometimes promiscuously. Each female deposits from 25 to 70 eggs.

The newly hatched larva is irregularly oval in shape, 0.12 of an inch long, of a transparent white color, and with fiery red eyes, which have been likened to grains of cayenne pepper. This young insect wanders about a very short time, and then settles upon the bark or leaves; when upon the latter, preferably along the midrib, and is soon covered with a white film of wax threads, some of which stand out from the rest, and if not carried away by the wind, they accumulate and form cottony tufts or tangles.

The shedding of the larva skin or first moult occurs about three weeks after hatching, and the formation of the true scale is begun. A second moult of the female occurs three or four weeks later, and when nine or ten weeks old egg-laying begins, the eggs being deposited beneath the scale, from beneath which the young begin to issue in about a week after the eggs are deposited, unless retarded by cold weather.

The male goes through its second moult and changes into a pupa several days earlier than the female, from which it emerges as a winged fly, and is ready for mating at the time the females are passing through their first moults.

There are three or four generations per year, but the separation into distinct broods is often more or less confused, one generation overlapping the succeeding one, so that all stages of the insect may generally be found at almost any season of the year upon infested trees. Generally speaking, the greatest numbers of migrating young may be found in one of three periods, namely: in the spring usually in March and sometimes extending into April; in June or July, and in September or October. During mild winters a fourth brood commences in January and straggles through this and the following month.

The recorded food plants of the insect are as follows:

Banksia integrifolia, Croton, Eucalyptus, Murraya Exotica, Orange and Ptelea trifoliata.

Natural Enemies.—Several minute hymenopterous parasites attack this scale, leaving the evidence of their work in the shape of minute circular holes in the backs of the scales, through which the small wasp-like flies have eaten their way after having destroyed, while undeveloped slugs or larvæ, the enclosed scale insects and their eggs. Various species of lady-bugs feed upon this and other scales in all stages of development, raising the scale and devouring both the mother insect and the eggs when young migrating scales or other food is not more convenient.

The "trash bugs" or larvæ of the lace-wing flies also devour many. These curious creatures may be recognized at once by the flocculent masses of grayish trash which they carry about on their backs as a means of protection. Similar insects, belonging in a different genus, Hemerobius, still lace-wings, but without the trash mask in the larval stage, are almost equally effective.

Remedies.—Kerosene emulsion, resin wash or whale oil soap. See section on remedies in latter part of bulletin.

THE LONG SCALE, *Mytilaspis gloverii* (Packard).

The long scale is of a more linear shape than the purple scale, with which it is often associated. The outline of the body is not so often curved as is that of the purple scale.

The Female.—The female scale is brownish, about 0.11 of an inch (3 mm.) in length, and less than one-fourth as wide. When crowded the scales adjust themselves to their surroundings by taking all sorts of shapes, and many will be dwarfed and malformed almost beyond recognition, except by microscopic examination. The young insects themselves are of a translucent waxy white, with the outer edge of the last joint yellowish. As they grow older, they incline to purple, which becomes deeper as the insects in-

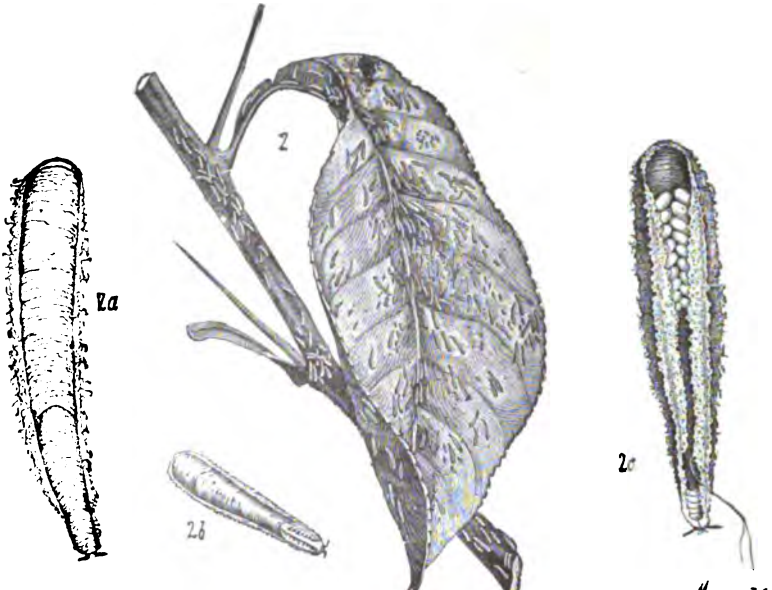


Fig. 2.

Mytilaspis gloverii (Comstock, Div. of Entomology, U. S. Dept. of Agr., Ann. Report, 1880).—2. Scales on orange, natural size; 2*a*, scale of female, dorsal view, enlarged; 2*b*, scale of male, enlarged; 2*c*, scale of female with ventral scale and eggs, enlarged.

crease in age. The adult female is about 0.05 of an inch (1.3 mm.) in length. The sucking proboscis is longer than the body.

The Male.—The scale of the male is smaller than that of the female, about 0.04 of an inch (1 mm.) in length, and usually straight. The color varies from shades of brown to yellow when young, becoming darker with age, and reaching a dark brown in the older females. Generally speaking, densely clustered colonies, including both sexes, have a reddish hue. The male insect is a minute, two-winged fly, 0.01 of an inch in length. Its body is pale pink in color, and about one-fourth as wide as long. The eggs are elongate-oval in shape, passing from a light to a purple color before hatching.

Life History.—The life history of this scale is so nearly parallel with that of the purple scale that it is unnecessary to enter into details. It has practically the same number of broods, which occur at about the same time as those of the other species. Sometimes the broods of the one species precede or follow those of the other by a few days, but they are often simultaneous. The times of applying remedies, therefore: can be stated to be parallel with those chosen for the purple scale. The parasites of the two species are, likewise, the same.

Remedies.—Same as for preceding species.

THE TURTLE-BACK SCALE, *Lecanium hesperidum* (Linn).

The turtle-back scale, with the others described in the following pages, belong to a sub-family of naked or waxy scales, known as Lecanæ, and are not covered with a true scale. The genus of *Lecaniums* are unprotected by any covering, except their skins, which become toughened with age so as to resemble parchment.

Description.—The full grown insect is from 1.12 to 1.16 of an inch (3 to 4 mm.) long, broadly oval, more or less swollen and convex upon the disk, surrounded by a thin, flat margin, which is notched on the sides and behind;

this shape, with the brownish color, gives it its popular name. The legs are concealed beneath the body.

Life History.—The young insect is of a yellowish color, and always settles upon the bark and leaves of tender growth. The adult insects appear to be unable to pierce the bark of the trunk or older branches, always being found upon wood of newest growth.

In the spring and early summer, when new growth is forming, the increase of the insect is most rapid, especially during the month of June. Later in the season the colonies disappear, only a few gravid females remaining to restock the plants at the next favorable opportunity. The young, hatching in the latter part of the season, often starve, because they are unable to reach tender twigs upon which to feed.

Fig. 3.

Lecanium hesperidum, (Comstock, Div. of Entomology, U. S. Dept. of Agr., Ann. Report, 1880 —Adult females on orange, natural size.

Parasites.—This scale, being unarmored, is particularly subject to attacks of the wasp-like chalcids, a number of which attack it freely. The parasitized insects can be recognized by their bloated bodies, more or less suggestive of miniature inflated balloons. By mid-summer the parasites are usually present in such numbers that the insect would be reduced below the possibility of inflicting much damage, even if its feeding habits did not restrict it.

Among the more important food plants of this insect are the maple, *Camellia japonica*, fig, grape, holly, laurel, orange, palms, peach, poplar, plum, rose and willow.

Remedies.—Resin wash, kerosene emulsion or whale oil soap.

THE BLACK SCALE, *Lecanium oleæ* (Bernard).

This scale is very similar to the preceding species, nearly black in color, approaching hemispherical in form, and longer than broad. Length from 0.16 to 0.20 of an inch

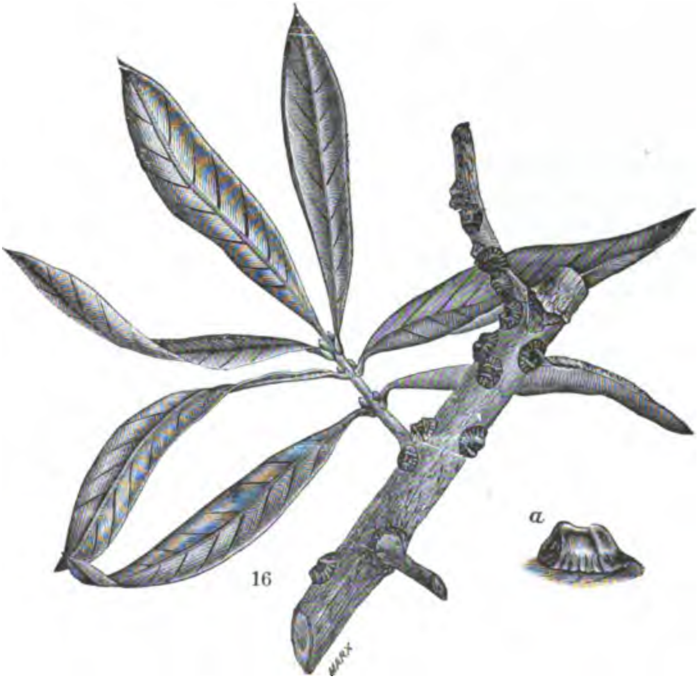


Fig. 4.

Lecanium oleæ (Comstock, Div. of Entomology, U. S. Depart. of Agr., Ann. Report, 1880).—Adult females on olive, natural size; *a*, female enlarged.

(4 to 5 mm.), height about 0.12 of an inch (3 mm.). The middle of the back carries an elevated keel, which is crossed at right angles by two elevated ridges, the latter dividing the body into nearly three equal parts. The body is slightly margined, the outer part of the disk being marked with many small ridges, which extend from the margin half way up to the centre of the back.

Egg.—Long, oval in shape, about 0.12 of an inch in length, and of a yellowish color.

Life History.—The young larvæ prefer the smaller twigs of the plants which they infest, and usually settle upon the leaves. The development of the species is slow, so there is probably not more than one brood per year. It lives upon all citrus plants, olive, pear, apricot, plum, pomegranate, apple, eucalyptus, rose, cape jessamine, live oak, holly, oleander and some other plants.

Parasites.—The species is preyed upon by parasites belonging in the family of chalcidæ mentioned in connection with the preceding species, the same parasites probably feeding more or less indiscriminately upon all the Lecaniums. Some predaceous caterpillars, such as *Lœtilia coccodivora* and others belonging to the family Tineidæ, also feed upon them, eating out the eggs and young larvæ before they have escaped from beneath the scale. Mites also consume the eggs and young. The different species of ladybugs feed upon them freely.

Remedies.—Mild applications of kerosene emulsion, resin wash or whale oil soap used as sprays.

THE HEMISPHERICAL SCALE, *Lecanium hemisphœrcum* (Targioni).

This scale is of a more rounded form than the other common species of Lecanium, approaching the form of a hemisphere; about 0.14 of an inch (3.5 mm.) in length, 0.12 of an inch (3 mm.) in width, 0.08 of an inch (2 mm.) in height. The color varies from a light, almost reddish brown, when young, to a dark brown, slightly tinged with red when old. The insects found upon twigs are usually more elongate than those found upon leaves.

Egg.—The egg is of an ellipsoidal shape, about 0.006 of an inch (0.15 mm.) in length, and of a whitish color, inclining to yellow.

It feeds upon orange, palms, orchids, *Camellia japonicas*, guavas, chrysanthemums and quite a number of other plants.

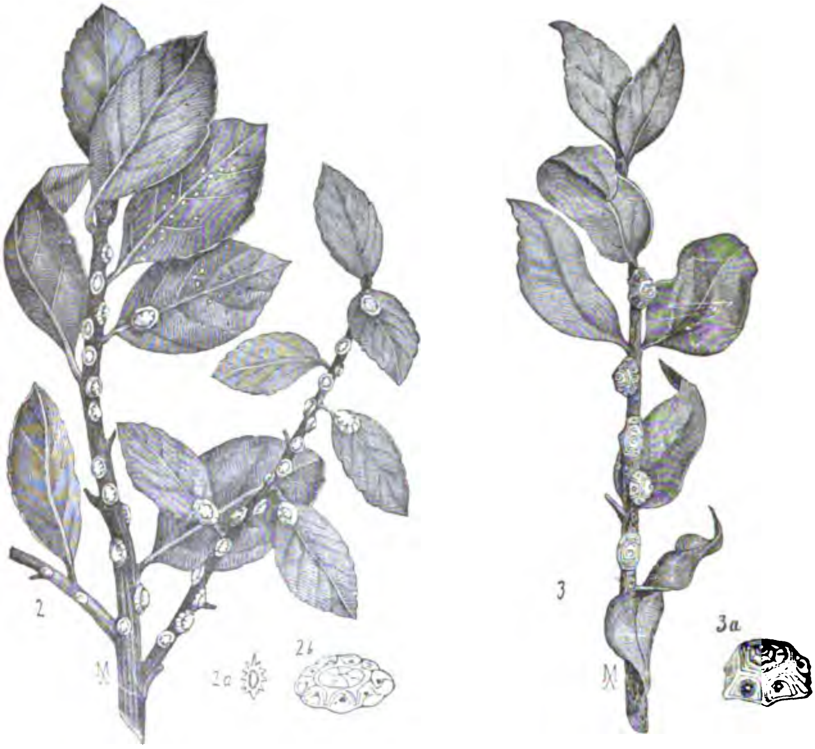
The parasites are probably identical with those that feed upon the preceding species, and the same remedies would be found effective.

THE WAX OR WHITE SCALE, *Ceroplastes floridensis* (Comstock).

This beautiful insect is 0.08 to 0.12 of an inch (2 to 3 mm.) in length, of an oval form, convex above, and concave beneath. The upper surface presents a rounded protuberence in the centre, around which are arranged six or eight smaller prominences or lobes, which are separated by a groove from the central projection. The white covering consists of soft wax, quite similar to the commercial article. The color in clean specimens inclines to a beautiful flesh-tinted white, the pinkish tinge being given by the reflection of the light through the wax from the red insect beneath. The insect itself bears on its upper surface six tubercles, three on each side, and shows a short anal tube, the end of which is seen projecting from the posterior or extremity of the waxy covering at the bottom of a deep pit. The walls of the body are very thin, and enclose liquids or eggs of a dark red color. The egg is 0.01 of an inch (0.25 mm.) long, and of ellipsoidal form.

Life History.—The eggs, 75 or 100 in number, are extruded from the body and hatched beneath the waxy scale. The young, escaping from beneath the scale, attach themselves by their beaks to the surfaces of the leaves, chiefly along the midribs and veins. As they approach maturity they go to the bark of the twigs and smaller branches. The exudations of wax first form in ridges, the marginal ones uniting around the central one.

About a dozen or fifteen similar tufts of wax arise around the centre, and the young louse, when about a week old, has been compared to an oval white star upon the leaf. At this stage it has some superficial resemblance to some of



Figs. 5 and 6.

(After Comstock, Div. of Entomology, U. S. Depart. of Agr., Ann. Report, 1880).

2. *Ceroplastes floridensis.*—Adult and young females on *Ilex*, natural size; 2*a*, young female, enlarged; 2*b*, adult female enlarged.

3. *Ceroplastes cirripediformis.*—Adult females, natural size; 3*a*, female, enlarged.

the stages of insects belonging in the Aleyrodidæ. The adult insect is covered with six large plates, three upon each side and three smaller plates located, one at each end and one in the centre. The wax finally becomes covered with dust and dirt, giving it an appearance quite different from that possessed when its development was just completed.

There are about three broods, each extending over three or four months. The first brood occurs in April and May, the second in July and August, and the third in October and November. This insect is restricted to Florida, and is very commonly found upon gallberry in great numbers. It also occurs upon quince, apple, pear, the citrus fruits, ferns, figs, myrtles, guavas and a number of other plants. As the insects become aged many of them fall to the ground and perish, being unable to reascend the plants from which they fell. The insect does not often become numerous upon orchard or grove trees, but sometimes gets thick enough to cause some alarm.

Parasites.—This insect, like the Lecanium, is subject to attack, some of the parasitic species previously mentioned also feeding upon this scale.

Remedies.—It is not often that the wax scales require particular attention, but we have some reports indicating that they may inflict considerable damage during a short period. If fully developed they will probably lose their hold and fall to the groung in a short time, so are not worthy of much attention while in this stage. When the growing larvæ become numerous they can probably be best checked by an application of resin wash; the wax coating would, perhaps, furnish protection in some degree against kerosene applications or whale oil soap.

THE BARNACLE SCALE, *Ceroplastes cirripediformis* (Comstock).

This insect agrees with the preceding species in possessing a white waxy covering, but is differently marked.

The average length is 0.20 of an inch (5 mm.); width, 0.16 of an inch (4 mm.), and height, 0.16 of an inch (4 mm.). The naked insect is dark reddish brown in color, of subglobular shape, and with a strong spine-like projection at the posterior end of the body. The general white color is often mottled with shades of grayish or light brown, the boundary lines of the plates remaining apparent, even at an advanced age. The back is covered by a convex dorsal plate, which is met on each side by six lateral ones, each of which is marked by a radiating nucleus in the centre. The posterior plate is larger than the others, possessing two nuclei, thus indicating that two plates are joined together. The eggs are 0.014 of an inch (0.35 mm.) in length, and of a light reddish brown color.

Life History.—The newly hatched larvæ are dark brown in color, and follow practically the same course of development as *Ceroplastes floridensis.*

It feeds on orange, quince, *Eupatorium* and probably upon a number of the same food plants as *C. floridensis,* but the species is much more rare than the white scale.

Remedies.—Same as for the preceding species.

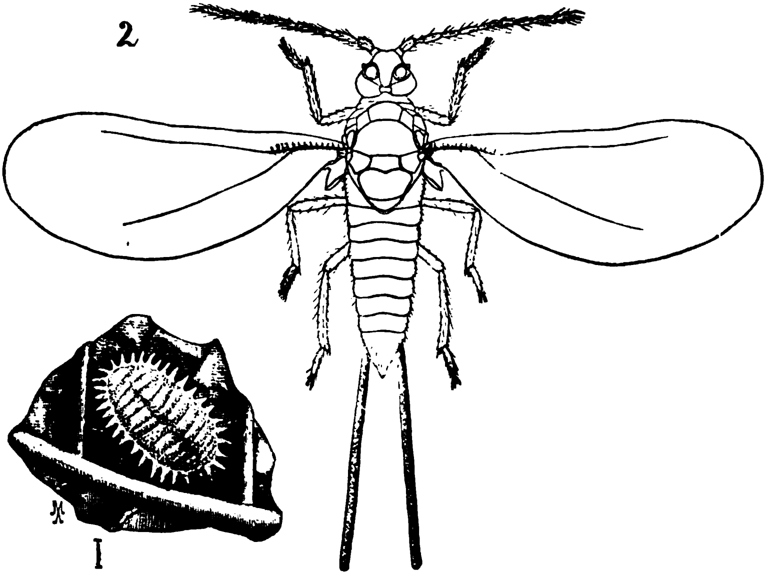
THE MEALY BUG, *Dactylopius citri* (Risso).

This insect, with other closely allied species, is very common in Florida. The adult female is from about 0.14 to 0.16 of an inch (3.5 mm. to 4 mm.) in length, 0.08 of an inch in width, and very flat. The color is dull brownish yellow, the legs and antennæ agreeing with the body in color. There are 17 appendages on each side, and most parts of the body are more or less powdered with particles lighter than the ground color. The egg is about .01 of an inch in length, of long ellipsoidal form, and light yellow color.

The two-winged male is about 0.033 of an inch (0.87 mm.) in length, and has a wing expanse of 0.1 of an inch (2.5 mm.). It is of a light olive brown color, with reddish attennæ and dark red eyes.

Life History.—The eggs are laid in a large cottony mass at the posterior extremity of the abdomen, and require considerable time to hatch. After hatching, the larvæ exhibit a marked tendency to settle along the midribs and veins on the under side of the leaves or upon the younger twigs, especially in the forks. When upon pineapples, it seeks the bases of the leaves, often descending a short distance beneath the surface of the ground. This habit makes it difficult to exterminate upon these plants.

It feeds upon house plants, orange, coffee, tobacco, croton, Ipomea, Learii, Habrothamnus, Pæonia, Solanum jasmoides and probably a number of others.



Figs. 7 and 8.

Dactylopius citri.—Female and winged male. (After Comstock, Div. of Entomology. U. S. Dept. of Agr., Ann. Report, 1880).

Natural Enemies.—This insect is especially subject to attack by the chalcid flies and such predaceous caterpillars as Lætilia coccodivora. Lady-bugs also feed upon the eggs and young.

Remedies.—The principal difficulty in handling mealy bugs is not in killing them when they can be reached, but in reaching them with insecticidal applications when upon such plants as pineapple. Upon orange and plants above ground they can be readily killed by kerosene emulsion, resin wash, whale oil soap, decoctions of tobacco and salty solutions. When upon pineapples, and it is wished to kill the bugs without injury to the plants, perhaps an application of kainit dissolved in water, one ounce in a quart, can be used quite freely about the bases of the plants without much danger of injury, if not used too frequently. A tobacco decoction, one pound in a gallon of water, is very useful, and would not be dangerous to the plant under any circumstances. Pyrethrum powder, used at the rate of one ounce in two quarts of water, and thrown in the infested parts of the plant with an atomizer, could also be adopted with good results in some instances. Frequent applications of mild insecticides are apt to prove more satisfactory, in this instance, than single severe treatments.

GENERAL OBSERVATIONS UPON SPRAYING.

In discussing the question of artificial remedies, it may as well be said at the outset that the determination of the advisability of using them depends largely upon the particular circumstances belonging to each individual case; and these circumstances can only become known as the result of observation and experience, the larger and wider the better. When available, the agencies employed by nature herself are always to be preferred before artificial help. Vigorous, healthy trees are seldom overrun by scales or insect enemies, and if trees are seriously attacked, it can generally be taken as an indication that they are diseased in some part, and that their strength and resisting powers are depleted. The reasons for such weakness may be due to physiological causes, to lack of proper fertilization, or to other and more obscure factors. If the exciting cause of the trouble can be discovered, of course the natural remedy consists in removing it by appropriately modifying the course of treatment and cultivation to which the tree has been accustomed, by supplying the fertilizing element which it lacks, or by doing whatever else may seem to promise well in the premises. An application of fertilizer sometimes proves an efficient corrective, but, on the other hand, it may, if used too freely, over-stimulate the plant, and later cause a reaction, which entails greater damage than the first trouble.

Trees that are properly pruned, and in which the small and shaded growth in the interior of the top is cut away, are not so apt to be attacked as those which are left to themselves. Shaded branches, like shaded plants, being unable to perform assimilative processes perfectly, are, by the enfeebled conditions thereby entailed, apt to become harboring places, from which armies of scales will sally forth whenever the physiological condition of the tree is for any reason deranged. For similar reasons, groves in which the trees are adequately spaced are more immune than those in which they are crowded. It is almost impossible to lay too much stress upon the necessity for free circulation of air and the admission of sunlight.

Observation of the numbers of natural enemies at work, coupled with the conditions and surroundings, as above discussed, will often give a clear indication to the experienced grower as to the advisability of using insecticidal washes.

We do not believe that insecticidal sprays are used to nearly the extent which their usefulness warrants, but, on the other hand, there seems to be a pretty well founded opinion that many who do spray are apt to overdo the good work, especially in the first enthusiasm which marks their introduction of the new process, and before experience has taught them that there is a danger line in "much spraying," as well as in multiplied numbers of bugs. Many men, who have suffered from such an experience, have become settled sceptics upon the whole subject of spraying, and are distrustful of any measures of this character; others have suffered in the same manner from no assignable cause, the sprays having been applied as moderately and intelligently as was possible in our present state of knowledge, and these men have naturally joined the contingent who condemn the practice. Some of these detractors allow nature to take her course without further attention, sometimes, and generally, paying a greater or smaller price for their negligence, sometimes happily finding, or rather being found, by a stroke of good luck exceeding any reasonable expectation. Other and more persistent men, having abandoned hope of relief through the spray pump, are led to study and apply the natural agencies, which have been briefly discussed in the preceding pages with such intelligence and success that it is admitted that they have little or no necessity for using sprays. These latter men, being artists in their profession, give a weight with many people to the idea of "no spraying at all" that does not seem to us to be warranted by either the facts of common observation or the general experience of the past twenty years. While we freely concede that some groves are in more danger from the pump than from the insects that swarm over and through them, and, again, that under ordinary circumstances it is within the limits of possibility to so guide the forces of nature as to render the application of sprays largely unnecessary, it should not be forgotten that between these two extremes of practice is included that great body of growers who will not risk the threatened sacrifice of their annual crops, and, perhaps, of their orchards as well, to the folly of inertia on the one hand, and who have not had tho experience nor, perhaps, the occasion, on the other hand, to acquire that knowledge of natural agencies sufficient to enable them to master an emergency which may have overtaken them suddenly; and since the great reliance of the successful non-sprayer consists, in the main, of prevention and not cure, his knowledge is of not great avail to the man who either has not taken the precautionary preventive measures, or whose efforts in such direction have failed for some reason, good or bad. It may be further observed in this connection that, perhaps, there is no man, however careful and foresighted, that would not find it to his advantage to use sprays at times. We do not believe it is possible for any man, under all circumstances, to successfully suppress or avert such an insect as the San Jose scale without resorting to spraying or fumigation, admitting that it sometimes practically disappears, without the orchardist's assistance, from infested orchards in Florida and adjoining States which possess a warm atmosphere of more than ordinary humidity, and, hence, favorable to the develment of fungus growths.

We have discussed this topic of spraying at some length, because, for some reason, it appears that many Florida growers express themselves in an unusually conservative manner regarding the use of sprays.

Assuming, then, that more or less spraying will be done, and is necessary, we will consider briefly the best ways of applying them, and the materials which should be used.

We have known some orange growers who made a regular practice of spraying the trunks, larger limbs and interior shoots of their trees every one or two years with a mild insecticide, such as whale oil soap, used at the rate of one pound in from three to six gallons of water, and reported that they found such application, if correctly timed, sufficient to keep their groves practically clean. Of course, such groves were not badly infested to begin with, or stronger applications would have been needed. Others follow the plan of watching for particular trees that are affected to a greater degree than the rest, and of confining their operations to these trees, not giving any application at all to trees not in seeming need of treatment. It would seem to us that the latter is the more desirable policy, though either one might be better than never spraying at all under any circumstances. We may remark here that it is seldom that a tree needs applications oftener than once in two years if the treatments are correctly timed; except for special reasons even the San Jose scale, in orchards, does not often need more than a biennial course of treatment, and it may be laid down, as a general principle, that a number of mild applications judiciously following each other give more satisfactory results, from the standpoint of both bugs and plants, than single severe treatments.

SPRAYS AND WASHES.

Kerosene.—Perhaps no substance has a wider range of usefelness than the preparations of kerosene in the form of emulsions, mechanical mixtures, and soaps. No one insecticide has been so generally used, and with such satisfactory results, as the standard kerosene emulsion in use for so many years. This has proven especially true on the Atlantic coast and in humid countries. While mechanical mixtures of kerosene have the advantage of being readily used, and, perhaps, are more penetrating for insects like the armored scales, they have not been extensively used in Florida for the particular insects described in this bulletin, and until they shall have been more widely tried, we are unable to pass positive judgment as to their desirability as compared with the emulsion. Of the insects herein treated, the emulsion may be recommended for the two species of Mytilaspis, for the Lecaniums, the mealy bugs and the wax scales before the waxy covering entirely shields the body.

Resin Wash.—After the kerosene preparations the resin washes have been in greatest favor as remedies for scale insects, and in dry climates, such as are found in the West, they have generally been more satisfactory than kerosene. The experience of the Eastern and Atlantic coast States has generally given the preference to kerosene, yet there are many fruit men in Florida who prefer the resin wash. It will be effective against all the insects listed herein, and should, perhaps, be preferred before kerosene against the wax scales if they are fully developed.

Whale Oil Soap.—The fish oil soaps furnish another spray very commonly used, the quickness with which this material can be prepared for use being a strong argument in its favor by many people. It should be observed that not all fish oil soaps are good insecticides, and, in fact, but two of those that are widely used are of such uniform composition and strength that they are generally recommended by entomologists. One of these soaps is known as Leggett's Anchor Soap, and is manufactured by Leggett Bros., New York City. Another is Good's Potash Whale Oil Soap, No. 3, manufactured by Jas. Good & Co., of Philadelphia. These soaps, used at a strength of two pounds dissolved in one gallon of water, almost equal the kerosene emulsions and resin wash against even armored scales. It is especially desirable for use when a number of successive mild applications are required at intervals, when the strength of the solutions can be readily varied.

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UNIV. OF MICH.
JAN 13 1909

BULLETIN No. 52 FEBRUARY 1900

FLORIDA
AGRICULTURAL EXPERIMENT STATION.

BAKING POWDERS.

By H. K. MILLER.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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INTRODUCTION.

In recent years considerable interest has been manifested in the United States, concerning the character of foods for sale on our markets, which are intended for human consumption. In the older countries it was found necessary, many years ago, for the enactment of laws regulating the sale of foods, because of the practice of adulteration. Little attention was given to this matter in our country until recently, but a few states and some of the larger cities, realizing the importance of protecting their citizens from fraud, and what is more serious, the possibility of having the public health permanently injured by the use of unwholesome or poisonous foods, have adopted measures to prevent the sale of adulterated foods within their borders. The practice of adulterating foods in this country has been found to be rather extensive by those who have investigated the subject. It is to the interest, both of the purchaser and the honest producer, to have this practice discontinued, and this has led to the organization of the National Pure Food and Drug Congress, the purpose of which is to suppress the sale of adulterated foods and drugs. This organization is endeavoring to have Congress pass a bill regulating the sale of foods and drugs in the United States. In view of what has been said it has been decided that a series of short bulletins relating to this matter might prove of some service to the citizens of the State.

It is possible that other subjects may be taken up, including those things of special interest to the agricultural classes, such as cattle foods, insecticides, etc. In the preparation of this, the first bulletin of the series, information has been gathered from the works of Blyth, Allen and others, as well as the United States Dispensatory. Special acknowledgment is due that excellent treatise on the subject, Bulletin 13, part 5, United States Department of Agriculture, Division of Chemistry.

BREAD RAISING.

From the very earliest times it has been the custom for man to aerate, or leaven, the greater portion of his bread. This is accomplished by causing carbon dioxide to form in and expand throughout the dough while it is being made into bread. If no provision is made for this leavening, the resulting bread will be tough, compact and hard; a condition in which it is much less easily digested than would otherwise be the case. On the other hand, well-prepared bread is light, porous and spongy, and is in a condition to be easily acted upon by the digestive fluids of the alimentary canal. The leavening of bread is best achieved by the use of yeast. In this way a small part of the carbohydrates in the dough ferments, the fermentation being due to the action of minute organisms introduced in the yeast. Carbon dioxide is disengaged and in its effort to escape makes the dough rise. When the dough is baked the carbon dioxide expands, rendering the bread porous and light. By this method no unnatural substance is added to the bread, so consequently there is no objectionable residue left. In so far as the quality of the bread is concerned, there is no method that will approach this natural process which has been longest in use. However, since considerable time is required for the fermentation to set in, more rapid methods have been introduced. These methods depend upon the use of chemicals or upon mechanical devices for introducing the carbon dioxide in the dough. In this country the only other method in common use is the one depending on the employment of chemicals.

CHEMICAL AERATING AGENTS.

Ordinary cooking soda is the substance nearly always employed for furnishing the carbon dioxide, but it is also necessary to use some chemical which will act on the soda in order that it may yield the gas contained in it. Besides the carbon dioxide gas, which is liberated, there is always formed one or more compounds which remain as a solid residue in the bread. The nature of this residue depends upon the character of the chemical used to react with the soda and also upon the relative proportions in which the two substances are compounded. This second substance is either an acid or an acid salt. It was the housewife to whom must be given the credit for first introducing the chemical process of raising bread, when she resorted to the use of sour milk and soda for making biscuit, and at times, when sour milk was not available, she substituted cream-tartar. From the principle involved in this has developed the vast baking powder industry, which has reached enormous proportions in the United States, and is also being rapidly extended throughout the world. When sour milk is used with soda, it is the lactic acid of the milk reacting with the soda which liberates carbon dioxide, and there is also formed a salt, known as sodium lactate, which remains in the bread. The quantity of acid present in sour milk is so variable that it requires much practice, skill and judgment to become an adept in preparing bread with its use, but the superior quality of the bread over that made by the employment of other chemical agents, amply repays one for the care exercised in gaining this experience. If we mix cream-tartar and sodium bicarbonate in the proportion in which they combine and add flour or starch to the mixture, in sufficient quantity to keep it dry, we have a baking powder. A baking powder then consists of an alkaline carbonate mixed with an acid constituent in about the proper proportions for combination, together with sufficient dry inert material to prevent chemical action, so long as the mixture remains dry. Contrary to the popular belief, there is no baking powder which does not leave a residue in the bread, and this residue is more or less objectionable, or perhaps injurious; the degree depending chiefly upon the nature of the acid constituent in the powder.

CLASSIFICATION OF BAKING POWDERS.

There are three acids used at present for the manufacture of baking powders, and for that reason all may be grouped under three heads:

(1). Those powders which have for the acid constituent some form of tartaric acid. These are known as tartrate powders.

(2). Those powders which have for the acid constituent some form of phosphoric acid. These are known as phosphate powders.

(3). Those powders which have for the acid constituent some form of sulphuric acid. These are known as alum powders.

We frequently find powders which may be classed in two of the above divisions, since the acid constituent is composed of a mixture of two of the above named acid constituents.

TARTRATE POWDERS.

This class of baking powders is regarded by many authorities as the least objectionable of all, and indeed, many consider them to be perfectly harmless. Cream-tartar is the substance most commonly employed to furnish the tartaric acid, and it is known to the chemist as potassium bitartrate. It is found in certain fruits and is almost entirely obtained as a by-product in the manufacture of wine from the juice of grapes. There can be no doubt that the juice of grapes is a desirable and harmless food; a promoter of health rather than a hindrance to digestion. It must be remembered, however, that after the bread has baked, the potassium bitartrate has lost its identity, and has been converted into a substance having different properties, so for this reason it will not do to conclude that the residue from a tratrate powder is perfectly harmless. The following equation represents the changes which take place:

$$\underset{\substack{\text{Potassium}\\\text{bitartrate,}}}{KHC_4H_4O_6} + \underset{\substack{\text{sodium}\\\text{bicarbonate,}}}{Na\ HCO_3} \underset{\text{and Water form}}{+4H_2O} = \underset{\substack{\text{Potassium}\\\text{sodium}\\\text{tartrate,}}}{KNa\ C_4H_4O_6, 4H_2O} + \underset{\substack{\text{Carbon}\\\text{dioxide,}}}{CO_2} \underset{\text{and Water.}}{+H_2O}$$

The sodium of the sodium bicarbonate, takes the place of one unit of hydrogen in the potassium bitartrate, forming the double salt, potassium sodium tartrate, which combines with four molecules of water and crystallizes. This remains in the bread and is commonly known as Rochelle salt. One molecule of carbon dioxide is set free and escapes, while the remaining elements unite, forming water. Rochelle salt is used in medicine and is a mild purgative. According to the United States Dispensatory, this substance, given in small and repeated doses, does not purge, but is absorbed by the system and converted into carbonates, which render the urine alkaline. This seems to me a rather serious objection, as it is well known that the normal urine is acid, and an alkaline urine is unnatural, and of itself is liable to produce serious disorders of the urinary organs.

One quart of flour requires from two to three teaspoonfuls of the powder, and from this it is estimated that a little more than half an ounce of Rochelle salt is formed in the bread. This quantity taken as a single dose would produce purging. Sometimes free tartaric acid is used as the acid constituent in these powders, but its use is exceedingly limited. The residue, in case this substance is employed, would be a salt known as sodium tartrate, which, like Rochelle salt, is a mild purgative, but is less objectionable. It is more difficult to prepare a baking powder which will not deteriorate, with the free acid, than with cream-tartar. Another objection to its use, is that it acts on the soda too rapidly while the dough is being made. The potassium bitartrate used, should not be the crude article of commerce, but should contain about 98 per cent of the pure substance, otherwise the resulting powder will have a low efficiency.

PHOSPHATE POWDERS.

This class of powders is somewhat less expensive than the tartrate powders, since the acid ingredient may be prepared from cheap minerals which occur widely distributed and in abundance. The bones of animals may also be used for the preparation of the phosphoric acid, so this substance commands a lower price than cream-tartar. An acid salt of calcium is the form in which the phosphoric acid is used and is called by the chemist monocalcium phosphate. It is obtained by treating either bone-ash or rock phosphate with sulphuric acid. A mixture results which is composed chiefly of calcium sulphate and monocalcium phosphate. This mixture is purified to a certain extent, but all the calcium sulphate is not removed. So the acid constituent of the phosphate powders always contains some calcium sulphate, or gypsum, and usually there is also present some aluminum sulphate. This last named substance is present because nearly all the crude materials from which phosphoric acid is manufactured contain aluminum phosphate, which, when treated with sulphuric acid, yields aluminum sulphate and phosphoric acid. It is difficult to remove this salt from the mixture.

It is not possible to say just what changes take place in bread containing phosphate powders during its preparation, on account of the complex nature of the chemical action due in part to the impurities usually present. The following equation probably represents the reaction which takes place when pure chemicals are employed:

$CaH_4(PO_4)_2$	$+2Na\ HCO_3$	$=Na_2HPO_4$	$+Ca\ HPO_4+H_2O$	$+2C\ O_2$
Monocalcium	sodium	disodium	dicalcium	Carbon
Phosphate and	bicarbonate form	phosphate,	phosphate, Water, and	dioxide.

The weight of the residue in the bread will be about equivalent to the total weight of powder used. One of the chemicals in this residue—sodium phosphate—is a mild purgative when taken in doses of from one to two ounces, and is frequently administered as a medicine. Its effect when taken in small and frequent doses has perhaps not been fully studied, but it is likely that the residue from these powders, when prepared from pure chemicals, is about as free from objection as the residue from tartrate powders. In fact, it is claimed by the manufacturers of phosphate powders, that the phosphates removed from the wheat in the preparation of bolted flour are restored by the use of their powders. It is an established fact that the system demands much phosphorus, but whether it can assimilate it to advantage, as it is presented in the residue from phosphate powders, is an unsettled question; and furthermore, other foods furnish ample quantities of this element to meet all the demands of the body. It is to be observed, too, that more phosphorus is added to the bread than is removed from the wheat by the milling process through which it goes. It is well to bear in mind that alum is frequently present in these powders, due most probably, to the presence of aluminum phosphate in the original material from which the calcuim monophosphate was prepared.

ALUM POWDERS.

The great majority of the baking powders on the market belong to this class, and they are as a rule much lower in price than those previously mentioned. Alum is a double sulphate of aluminum and an alkali metal, and when a solution of alum is added to sodium bicarbonate, a reaction takes place, giving rise to the liberation of carbon dioxide. In baking powders we sometimes find ammonium alum and sometimes potassium alum, and even a mixture of these is not infrequently found. Ammonium alum is made by crystallizing the salt from mixed solutions of ammonium sulphate and aluminum sulphate. Its composition is expressed by the formula:

$$(NH_4)_2Al_2(SO_4)_4,24H_2O$$

Potassium alum is made in a similar manner, though substituting potassium sulphate for ammonium sulphate, and its composition is expressed by the formula:

$$K_2Al_2(SO_4)_4,24H_2O$$

Each kind contains twenty-four molecules of water of crystallization. The alum crystals are ground to a fine powder and mixed with starch and sodium bicarbonate, in the proper proportions, and when this is moistened, as is the case when the dough is made, the following indicated changes take place, if ammonium alum is used:

$$(NH_4)_2Al_2(SO_4)_4+6Na\ HCO_3=Al_2(OH)_6+3Na_2SO_4+(NH_4)_2SO_4\ +6CO_2$$

Ammonium aluminum sulphate and sodium bicarbonate form aluminum hydroxide, sodium sulphate, ammonium sulphate and carbon dioxide.

If, however, potassium alum is used, the changes are represented thus:

$$K_2Al_2(SO_4)_4\quad +6Na\ HCO_3 = Al_2(OH)_6\ +3Na_2SO_4\ +K_2SO_4\quad +6CO_2$$

Potassium aluminum sulphate and sodium bicarbonate form aluminum hydroxide sodium sulphate Potasium sulphate and carbon dioxide.

It cannot be said that this represents the actual changes which take place during the baking, though it is believed by many to do so. The weight of the residue left in the bread from alum powders is greater than the weight of the total quantity of powder used. This is explained by the fact that water unites with some of the products to form crystalline salts, and the amount of water so taken up is greater in weight than the carbon dioxide which is liberated. One may readily see, also, that the residue left in this case is much more complex than that left from the other powders. One of the products—sodium sulphate—is a mild purgative and it may be regarded as harmless. It is known as Glauber's salt. If the powder contains potassium alum, one of the products will be potassium sulphate, and this is known to be more active on the system than sodium sulphate. It was formerly administered in medicine as a cathartic, but its use has nearly ceased at the present time. In case ammonium alum is used in the powder, we have a product—ammonium sulphate—which is even more objectionable than potassium sulphate. The ammonium compounds have been found to be decidedly more irritating than the sodium or potassium compounds, when taken in normal medical doses. It is to be remembered, though, that rather small amounts of these salts would be formed in the quantity of bread sufficient for an individual meal, and it cannot be said with certainty that such small quantities are deleterious. Nevertheless, the very fact that we do not know, should make one cautious. The remaining substance, and one which is always left as a residue from alum powders, is known as aluminum hydroxide. This substance has given rise to much controversy; some claiming it is without injury to the human system, and others maintaining that it is injurious, and is liable to produce serious derangement of the digestive system. There can be no doubt that alum, as such, when taken into the stomach, even in small and often repeated doses, will interfere with the natural processes of digestion, and for this reason, is harmful and should be avoided. The question then to be decided is whether any alum is left in the bread undecomposed, or whether the aluminum hydroxide, which is formed, is soluble in the digestive fluids. It is hard to be convinced that the powders are so carefully compounded, and the mixing so perfect, that there will never be any alum left in bread, in which the powders are used. It is claimed by those who make these powders, that the aluminum hydroxide, during the cooking process, loses water, and is converted into a substance insoluble in the fluids of the stomach. Others claim that the temperature at which bread is cooked is not sufficiently high to bring about this change. If this latter claim is correct, few physicians would recommend the use of alum powders. It is not for us to say positively that the use of alum powders is to be condemned, with our knowledge of the subject so imperfect. This question is to be largely settled by the physiologist and it will require a great deal of patient research to solve the problem. One thing which may aid us in forming a conclusion is the fact that England and France, the two countries which have been most careful in regulating the sale of human foods, virtually prohibit the sale of alum powders. Many eminent disinterested scientists condemn their use in no uncertain language.

BAKING POWDER FOR SALE IN FLORIDA.

In order that the public may have an opportunity of knowing something of the character of the brands of powders they are using, a number of brands which were found on sale in Lake City were purchased, and examined in the laboratory, to such an extent, that they might be properly classified. A complete quantitative analysis was deemed unnecessary, but the quantity of available carbon dioxide was carefully determined in each sample, in order that the relative efficiency of the different brands, as leavening agents, might be known.

The method used for estimating the available carbon dioxide is the same as followed by the Division of Chemistry, United States Department of Agriculture, and published in Bulletin 13, part 5, page 589.

There was no posibility of ascertaining how long a time had elapsed since the preparation of these samples; and as baking powders may slowly lose their efficiency, some of these brands may not show up as well as others, on account of having been prepared for a longer time.

The samples were purchased, however, just as any customer would purchase them, and it is believed the comparisons are equally just to all, at least as nearly so as possible. All the samples were examined for tartaric acid, phosphoric acid, sulphuric acid, ammonia and aluminum. Special care was used in testing for these substances.

Below, is given a table of the brands examined, showing to which class each belongs, as well as the percentage of available carbon dioxide, with such remarks as are deemed advisable. It would have been desirable to have obtained brands from other localities, so that the list would be more complete, and if possible, include all the brands to be found on sale in the State. This was found impracticable, but if any of our citizens is using a brand not named in the list below we will examine the same and classify it, provided an unbroken package be sent to the laboratory by mail, or by express, charges prepaid.

I. TARTRATE POWDERS.

LABORATORY NUMBER.	BRAND.	NAME AND ADDRESS OF MANUFACTURER.	PER CENT. OF CARBON DIOXIDE.
1101	Royal . . .	Royal Baking Powder Co., New York	12.85

II. PHOSPHATE POWDERS.

LABORATORY NUMBER.	BRAND.	NAME AND ADDRESS OF MANUFACTURER.	PER CENT. OF CARBON DIOXIDE.
1102	Silver . . .	F. Middleton & Co., Philadelphia . .	8.16
1096	Rex	J. D. & R. S. Christian Company . .	10.11
1098	Calumet . .	Calumet Baking Powder Co., Chicago.	4.36
1099*	Obelisk . .	Ballard & Ballard Co., Louisville . .	0.45
1100	Horsford's .	Rumford Chemical W'ks, Providence.	12.31

ALUM POWDERS.

LABORATORY NUMBER.	BRAND.	NAME AND ADDRESS OF MANUFACTURER.	PER CENT. OF CARBON DIOXIDE.
1090	Rose Leaf .	Rose Leaf Chemical Co., Savannah. Ga	11.42
1091*	Three Cent.	Roanoke Chemical Co., Roanoke, Va	9.25
1092	Railroad . .	Morehouse Mfg. Co., Savannah, Ga. .	13.73
1093	Parrot and Monkey .	The Sea Gull Specialty Company, Baltimore, Md.	14.26
1094*	Good Luck .	Southern Mfg. Co., Richmond, Va. .	12.45
1095*	Free Silver .	Roanoke Chemical Co., Roanoke, Va.	10.87
1097	Success . .	Morehouse Mfg. Co., Savannah, Ga. .	14.64

By referring to the last column in the above table one can form a fair opinion of the efficiency of any brand there, as a leavening agent. A good powder should contain from 11 to 12 per cent. of available carbon dioxide. Any one containing less than 11 per cent. may be regarded as not up to the standard, as there is no excuse for a powder containing less. It is to be observed that alum powders may be made which have very great leavening power. All the brands under the head of phosphate powders were found to contain more or less aluminum, and the three numbers, 1096, 1098 and 1099, contain this element, and sulphates enough, for them to be regarded as mixed alum and phosphate powders. The quantity of aluminum in numbers, 1102 and 1100, is so small that it is very likely that it was derived from the phosphate rock, used for making the monocalcium phosphate. It is a striking fact that the two brands, 1099 and 1098, which were claimed by their manufacturers to be absolutely pure, and the only genuine article to be found, proved to be as worthless as so much dirt. Those brands having a star placed after the numbers contain ammonia, which is present as ammonium alum or as an impurity in the sodium bicarbonate, or else it is there as ammonium carbonate, which is sometimes added to baking powders, because it is volatile when heated and aids in raising the bread. It is not a good thing to have in our food.

THE CONSUMPTION OF BAKING POWDERS.

It is estimated that the people of the United States consume more than one hundred millions of pounds of baking powders annually, and that the cost of this probably amounts to more than twenty-five millions of dollars. The United States undoubtedly heads the list of nations in the quantity of baking powders consumed. This fact, together with the small attention given to food laws, and food inspection, whereby improper, unwholesome and adulterated foods may be, and are openly sold in our markets, possibly has a close connection with the cause which leads to this nation being spoken of as the "nation of dispeptics." I think it may be said that no baking powder is without harm to all classes of people, and that bread leavened with yeast is best for general use. If it is not convenient to have bread prepared without using baking powder, then that class of powder should be selected which will prove least objectionable·

It may be well not to depend upon one class of powder for constant use, but select two and use them alternately.

OUR NEED.

Until the physiological actions of the products left in bread from the various classes of powders are better understood, it is not possible to set a standard for baking powders. One thing, nevertheless, can and should be done, either by the State or National Govenment. That is, make it possible for every purchaser of baking powders to know just what he is paying his money for. This can be provided for by requiring every package of baking powder to bear on its label the kind and quantity of ingredients used in its preparation. As much is done for the farmer when he goes to purchase food for his cotton; shall his children not receive as much consideration? If this is done, it will not be long before people will enlighten themselves as to the nature of these powders which they now blindly use in their daily bread, and they will exercise more care in selecting them. It might also be expected that those interested in the manufacture of the different classes of powders, would find a means of learning whether or not any of the substances, now used in the manufacture of these powders, leave products in the bread which render their use dangerous to the public health.

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BULLETIN No. 53. MARCH 1900.

FLORIDA
AGRICULTURAL EXPERIMENT STATION.

SOME CITRUS TROUBLES

By H. HAROLD HUME.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

1900.
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SOME CITRUS TROUBLES.

REMARKS.

The severe freeze of February, 1899, following upon that of 1894–95, just when many orange groves had been brought again into bearing condition, has led to the abandonment, for the time being, of a large number of groves in the more exposed portions of the State, and to renewed activity in sections removed from the detrimental effects of frost. So, while there has been a falling off in the citrus industry in certain localities, the new life which has been infused into it in others will shortly place it upon as stable a basis as that on which it stood a few years ago. Groves that had been previously neglected, or at least cared for in only an indifferent sort of way, are being put into shape, either by new or old owners, and young groves are being extensively planted. Consequently more interest is being awakened in all those things which pertain to the health of the orange tree, and there is a constant demand for information relative to the successful treatment of citrus diseases.

Foot-rot, die-back, and sooty mold are the sources of greatest injury to the citrus industry to-day. The latter is a particular drawback in certain localities, and, while oranges sold briskly this season at from $2 to $2.50 per box on the tree, it must be borne in mind that with a greater increase in product, a more discriminating market will result, and more care must needs be exercised in producing clean, bright fruit. The quality of Florida's product is high, and a strong effort should be put forth to maintain and elevate the standard of excellence.

With the object in view of helping, in some slight measure, the orange growers and those who have to face the problems of grove raising, many of them for the second or third time, trips have been made to various parts of Florida, and the results of my observations, together with what knowledge could be gained from many other sources, are here set forth. Many favors have been shown me by those engaged in the growing of citrus fruits throughout the State, and to them my obligations are here expressed.

To the Hon. Geo. W. Wilson my thanks are due for his kindness in placing at my disposal all the volumes of the *Florida Dispatch* and of the *Farmer and Fruit Grower*, both as published separately and consolidated.

This bulletin is intended to be the first of a series relating to the orange industry.

FOOT-ROT.

The name given above is the one under which the disease is commonly known in Florida. In Italy it is called "*Mal di Goma,*" while in California it usually goes by the name of "gum disease." So far as known it is found in nearly all the citrus districts of the world, and its history in Europe extends back to about 1845. It worked destruction in the groves of the Azores some years previous to that, and, in fact, it seems to have first been noted there. When it made its appearance in Florida is not definitely known, but in 1888 Dr. A. H. Curtis[1] referred to it as follows: "The disease of orange trees, commonly known as "foot-rot," seems to have made its first appearance in Florida about twelve years ago. Few persons, however, remember to have observed it earlier than the year 1880." Dr. T. W. Moore,[2] writing in 1881, states: "Two other diseases have of late years shown themselves in Florida, and occasioned great fear and trouble among the orange growers. One is known as 'foot-rot.'" In the *Florida Dispatch-Farmer and Fruit Grower*, one of the foremost horticultural papers of the State, now incorporated with the *Times-Union and Citizen*, Mr. T. S. Coogler,[3] of Brooksville, Fla., makes the following statement: "When I first began the growing of citrus trees in this county (Hernando) in 1867, there was no such thing known as foot-rot, and if it then existed it was wholly unnoticed. The year 1878 was a very wet one, for it rained almost continually during the entire year. * * * When the sap began to flow in the citrus trees the following (1879) spring, it was noticed that in many trees it exuded from the bark at or near the ground, but no one paid any attention to it. This was really the commencement of the foot-rot in this county, so far as we can ascertain." From these references it will be seen that it has, in all probability, been present in the State for a period extending over the last twenty-four years.

---

[1] Foot Rot, Sore Skin or Gum Diseases. Bul. Fla. Exp. Sta., 2:29-35. My. and Je. 1888.

[2] Diseases to which the orange tree and fruit are liable, and their remedies. Treat. and Handbook of Orange Cult., 128-132, 1881.

[3] Foot Rot Attacking the Sour Stock. Fla. Dis.-Far. and Fr. Gr., 3 XLV 891 N. 1891.

Previous to the freeze this disorder caused great destruction in the groves of northern Florida; it is still found generally distributed throughout the sections where orange growing is successfully carried on.

Foot-rot is clearly marked and not likely to be confounded with any other disease. It is confined to the crown and main roots of the tree, extending a foot or so above the ground and downward along the roots. Its presence is first indicated by an exudation of gum, which forms in drops on the bark covering the diseased spot. Further examination at this time reveals a brownish coloration of the outer cortex and a decayed condition of the inner. The affected areas emit a fetid odor similar to that from a decaying orange. All plants, when attacked by a disease, strive to overcome it, and this the orange tries to do by cutting off the affected portion by a wall of new tissue similar to that formed around an ordinary wound. Following this, the bark covering the spot dries up, breaks away from the adjoining parts, and drops off. The wood is then found to be decayed for a short distance beneath.

Though the tree still continues to bear fruit, its appearance is far from healthy; the leaves become yellow, the twigs and young branches die, and the whole tree assumes an unthrifty appearance. Where the affected tree can be seen from a distance, it stands out in marked contrast to its neighbors.

Fortunately all varieties of citrus stock are not in the same degree subject to this dreaded disease. In order of foot-rot resistance they stand about as follows: Sour orange, *Citrus bigaradia*; pomelo, *C. decumana;* rough lemon, *C. sp.*; lemon, *C. limonum;* sweet orange, *C. aurantium.* Roughly, we may class the first three as decidedly resistant, the last two as very much subject to the disease. It is preeminently a disease of the sweet stock. We are unable to place *C. trifoliata* definitely, but would venture the opinion that it possesses considerable merit in power of resistance as well as in so many others.

Cattle-penning; deep-setting; a wet, soggy-soil condition; the use of rank, organic nitrogenous fertilizers;

planting in localities underlaid with hard-pan; faulty drainage; a shaded condition of the soil, and many similar circumstances and practices have been given as the cause of foot-rot. While it is not probable that the disorder is due to any of these, there is no doubt that they have a deleterious effect on the general health of the tree, and so act as a predisposing cause. A healthy, vigorous tree has all the chances in its favor for withstanding the inroads of disease, and any decrease in its vitality simply gives its enemies an opportunity to gain a foot-hold.

The specific cause of the disease is still in doubt, but it is probably due to some form of vegetable parasite. Prof. Giovanni Brioze,* in 1878, found a fungus, ***Fusisporium limonii***, constantly associated with the disorder, but was not certain as to whether it was the specific cause or not. Regarding it he states: "But that its presence ought to accelerate the disorganization of the tissue and contribute to extend the evil, I think I see without any doubt."

As pointed out above, there are many conditions which bear an important relation to foot-rot, and a brief discussion of some of these will not be out of place. (*a*) Cattle-penning and pasturing, so often resorted to for the purpose of fertilizing the groves, is, to say the least, a questionable practice. The sharp hoofs of the animals cut and bruise the bark on the crown roots, and thus, through their agency, this possibly parasitic disease may be more rapidly carried from affected to unaffected trees. Then, too, the rank manure may act injuriously, and there is no doubt that there are better means for supplying the requisite plant food than this. In fact, we believe that the best orange is produced in Florida by the judicious use of commercial fertilizers. (*b*) Close planting is often resorted to as a means for shading the ground. A moist or damp condition of the soil is produced about the tree, which, in our warm Florida climate, is exactly suited to the development of disease. It would be decidedly better to provide a surface mulch either by the growing of leguminous crops or

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*Intorno al Mal di Goma Delgi Agrumi. Statzione Chimico-Agraia Sperimentale Di Roma. pp. 1-16. *pl. 1.* 1878. (Estratto del Vol. 11, Series 3a Atti della R. Academia dei Lincei.

by providing a mulch of leaves and leaf-mold. Air would then be freely admitted, and the sunlight, one of the best germicides we have, would be allowed to reach the soil. (*c*) The piling of rubbish, old tin cans, palmetto roots, etc., about the trunks of trees is to be strongly condemned. Where a mulch of leaves or grass is placed close to the trunks it should, from time to time, be removed to allow the soil to dry out on the surface. (*d*) Strict attention should be paid to drainage, that no stagnant water be allowed among the trees. A soggy, ill-drained soil is not conducive to the health of an orange tree.

Remedies.—These consist in removing, as far as possible, the detrimental conditions to which reference has just been made, and particular attention should be paid to everything conducive to the health of the grove.

Carefully remove the earth from about the tree, avoiding injury to the healthy roots. With a sharp, strong knife, cut out all the diseased tissue down to the healthy wood. Burn the material removed. With a brush, paint the freshly cut wood, using one of the following solutions:

1. *Carbolineum Avenarius.**

2. *Crude carbolic acid* and *water* in equal parts.

3. *Sulphurous acid* and *water*, three of the former to seventeen of the latter.

4. *Lime, crude carbolic acid*, and *salt.* Slake one peck of lime in two gallons of water and add crude carbolic acid, four ounces; salt, three pounds. If too thick, add a little more water.

Leave the earth removed until such time as the tree has recovered, and then it would be better to fill in with fresh, porous earth. In close-planted groves remove a sufficient number of trees to let the light reach the ground. These can be set out in another plot of ground. Disinfect cultivators, plows and harrows with carbolic acid after using them in diseased groves, and before use among healthy trees. As a preventive measure, use resistant stocks as already indicated, and where trees have died out,

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*A fungicidal and insecticidal compound, used also as a wood preservative.

re-set with others budded on sour orange, pomelo or rough lemon, as the soil conditions render necessary.

SCAB.

This citrus disease has been known in Florida for the past fifteen years or more, having been observed first on the sour orange, *C. bigaradia.* The bitter-sweet and lemon are also very much subject to the disease. This year it has been collected on young, tender leaves of the pomelo, *C decumana*, and on the foliage of the Satsuma, *C. nobilis*(?). and Kumquat, *C. Japonica.* A large number of young Satsuma trees badly affected by the disease were found. and the leaves showed that considerable damage had been worked by the fungus (see Plate No. III). On the Kumquat, only a few diseased leaves were found, though several hundred trees have been examined. It is very probable that on one of the last-named varieties it was introduced into Florida from Japan, and, here finding host plants and climatic conditions adapted to its development, has become a serious inconvenience in the successful growing of certain citrus fruits.

While the sour orange, wherever found in Florida, is very badly affected by scab, little notice is taken of the disease on that host, as it is used principally as a stock on which to work other varieties, and is usually cut off when a year or two old. It is, however, a slight drawback in the production of healthy, vigorous stock. But it is with the injury done to the fruit of the lemon that we are most concerned from an economic standpoint. Lemons, to sell well, must be perfectly bright, clean and smooth, and when they are badly affected by this disease, they are rendered unsalable. A rough, distorted fruit finds no place in our markets.

Scabby leaves, twigs and fruit are very characteristically marked. Warty, corky elevations cover the surface, giving to it an unsightly, roughened appearance. Often the leaves are twisted or drawn out of shape, and they are in a considerable degree deprived of the power to fulfill their natural functions, namely, respiration, transpiration and the assimilation of food. Beneath the warts on the opposite side of the leaf, there is often a well marked conical depression, corresponding to the elevation on which the excrescence is situated. Under the warts on the fruit there is an abnormal thickening of the tissue, resulting in the formation of somewhat conical elevations. Thus the corky portions are lifted above the normal level of the rind. The warts are at first yellowish, then grayish, becoming dusky in appearance as the disease advances, until they become almost black, and eventually crack and open. When the excrescences are isolated they are minute and of the shape of a cone or truncated-cone. Generally, however, they are confluent, presenting the appearance of a bark-like substance firmly attached to the epidermis.

The specific cause of the disease is a minute parasitic fungus, a species of *Cladosporium* described by Prof. F. Lamson-Scribner[1] in 1886. The spores are very small, smoky in color, and usually one- or two-, though sometimes three-celled. They are borne on brownish colored sporophores (spore-bearing filaments). When mature they become detached, and through the agency of the wind they are carried about from one tree to another. They fall upon the leaves of their host, and, under favorable conditions, germinate by sending out a delicate, slender tube, which enters the leaves and gives rise, in due time, to the well-marked diseased condition.

Remedies.—The experiments carried out by Webber and Swingle[2] have gone to show that the disease can be successfully controlled by using one of the copper spraying solutions, Bordeaux mixture or ammoniacal solution of copper carbonate. The latter must receive the higher recommendation, as it is less likely to injure the tender leaves and blossoms of the lemon, but a weak solution of Bordeaux mixture is likely to prove quite as efficacious without any harmful results.

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[1] Notes on the Orange-Leaf Scab. Bull. Torr. Bot. Club. 13:181-188. Oct. 1886. Orange-Leaf Scab. Cladosporium sp., Rep. Myc Sect U. S. Agric. Dept. 1886, 120-121. *pl.* 6. 1887.

[2] The Principal Diseases of Citrus Fruits in Florida. Bul. Div. Path. and Phy. U. S. D. A., 8: 23-24. 1896.

The question at once arises, "Am I not likely to do injury by killing as well the parasitic species of fungi that work destruction to the various scales that infest the trees?" This will have to be borne in mind, and, if necessary, follow the spraying with an application of whale-oil soap, kerosene emulsion or resin wash. To prevent scab, spray three times. Give the first application just after the petals have fallen from the first blossoms and two others inside the next six weeks. If the disease gains ground on the young fruit, further spraying will be necessary. Shoots of sour orange and diseased fruit should be removed and burned.

Ammoniacal solution:

Copper carbonate, 5 ounces; ammonia, 3 pints; water, 45 gallons.

Dilute the ammonia with five gallons of water and add the copper carbonate. Use a wooden or glass vessel. Stir thoroughly until dissolved. This will give one ounce of copper carbonate to each gallon. For use, add forty gallons of water, or, in smaller quantities, one gallon of mixture to eight gallons of water.

The following mixture of Bordeaux is recommended:

Copper sulphate, 4 pounds; unslaked lime, 4 pounds; water, 50 gallons.

Dissolve the copper sulphate in twenty gallons of water. Slake the lime in a small quantity of water; add water to make twenty gallons. Mix the two solutions in a third vessel or in the barrel of the spray pump, taking a pailful alternately from each of the solutions.

DIE-BACK.

This disease takes its name from the fact that the young twigs and branches of affected trees die back to a distance of from two to eight inches, or even more, from their tips. It was first described in the year 1875 by J. H. Fowler,[1] and it seems to be peculiar to Florida conditions.

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[1] On the Die-back in Orange Trees. Proc. Fla. Fr. Gr. Ass., Ja. 1875.

In 1873-74 it was made the subject of inquiry in several letters to the Agricultural Department at Washington. One of these we quote as referred to by Mr. W. H. Ashmead[2] in an essay written in 1884: "Mr. W. F. White. of Tampa, wrote under date of April 15. 1873, to the department as follows: 'We have the disease of the orange tree known as "die-back." It has lately appeared at this place. We have no underdrains, but it is equally as bad on the pine land, hammock, or shell land. Some of our trees are almost killed by this disease, while in other cases only a few limbs are injured. The trees once affected make very little growth afterwards.' "

No citrus trouble is more widely distributed throughout the State than die-back. No locality is exempt from it, and no variety free from its attack. Trees, young and old, suffer alike, and a few trees have been found affected which were still standing in the nursery rows. Very often little notice is taken of it, and it gradually works its way, nipping off the new growth, and the trees, in consequence, make very little progress. Years of work and much capital are often wasted in mistaken efforts to bring a grove into healthy condition.

The disease is easily recognized. The young twigs die back several inches. Irregular, reddish-brown elevations, at first closed, later cracked open and filled with a resinous substance make their appearance on the small branches and twigs. These vary greatly in length, height and shape. Often elevated pustules, filled with a gummy substance, occur on the young growth. These seem, in some cases at least, to develop into open ruptures. Adventitious buds are frequently produced, and those which are not smothered by the resinous exudation develop, thus giving rise to several branches from a single node (see Plate No. V). Sometimes the only noticeable mark of the disorder on a branch is the presence of a resinous knot in the axils of the leaves where the buds should be. Slightly affected branches have often a dark, greasy appearance. The small growth is usually twisted and bent. On the fruit the disease is manifested by the presence of dark, brownish blotches and by cracking or splitting. Many fruits drop off. As the disease advances the trees try in vain to throw out new branches. Symptoms become more strongly marked, the tips of the bare, distorted branches protrude above the dark-green foliage. Gradually the larger branches are embraced, water sprouts develop only to become affected and die. Eventually the tree succumbs.

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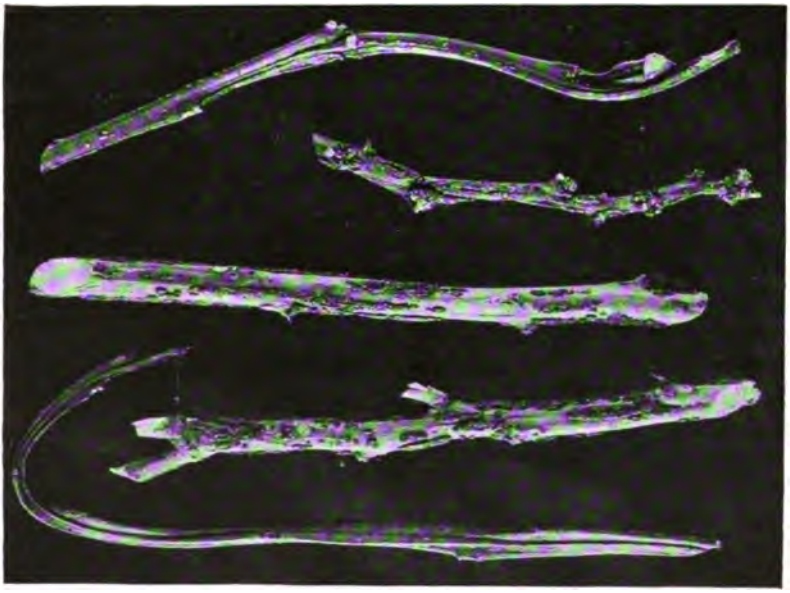
[2] The Diseases of the Orange. Proc. Fla. Fr. Gr. Ass., F. *1884*. Copied in Fla. Dis. 4. iv. 73-74, Ja. 1885.



Cut 1.

Dieback on Sweet-Orange Twigs, showing distortions and excrescences. (Natural size.)

Dieback is not, so far as known, a fungus disease, no spores nor any thing of the sort having been found connected with it. It appears rather to be a disorder brought about by a variety of circumstances, and the external marks of the disease are to be regarded as an indication of a deranged condition of the whole tree. In certain localities it seems to be brought about by the presence of hard-pan in proximity to the surface. Again, the condition seems to be due to a wet, poorly aerated soil. But perhaps the most prolific source of the trouble is the use of fertilizers unsuitable to the orange tree. Now, whether we should make a distinction in die-back as induced by these several causes, it is difficult to say.

Many instances have come under the observation of the writer, of the occurrence of the disease where trees were planted in ground previously used in growing vegetables, and which was heavily fertilized with blood and bone and cotton-seed meal. Then, too, in some localities the spaces between the tree-rows have been used for growing vegetables, the same fertilizers applied as in the cases just mentioned, and with the same deplorable effect on the orange trees! The disease has been observed in groves regularly fertilized with rank nitrogenous fertilizers, and trees standing near and receiving nutriment from stables, closets and hencoops are generally affected.[*] The general conclusion reached by all observers during the past fifteen years or more has been for the most part to the effect that the excessive use of organic nitrogenous fertilizers will cause die-back, and the matter has been pretty thoroughly discussed in the horticultural papers of the State.

Remedies.—These consist for the most part in removing conditions and discontinuing practices which induce the disease. Make a thorough study of the soil and the methods of fertilizing. In some places, with trees growing on hard-pan, the following plan was adopted and they made a complete recovery: The trees were cut back, lifted from the ground, the hard-pan removed, either by blasting or picking it out, and the trees reset. The remedy for trees growing in damp ground consists in paying proper attention to drainage and fertilizing. Tile or box drains should be put in to remove the water and allow the air to enter. Where the disease has been brought about by the use of fertilizers, as before indicated, discontinue their use, discontinue cultivation, allow the natural vegetation to spring up and apply potash and phosphoric acid as usual. Continue this treatment until recovery takes place; then resume cultivation and fertilization, using nitrate of soda or sulphate of ammonia as a source of nitrogen.

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[*] The injurious effects following certain practices adopted in manuring orange trees in the South were early recognized.

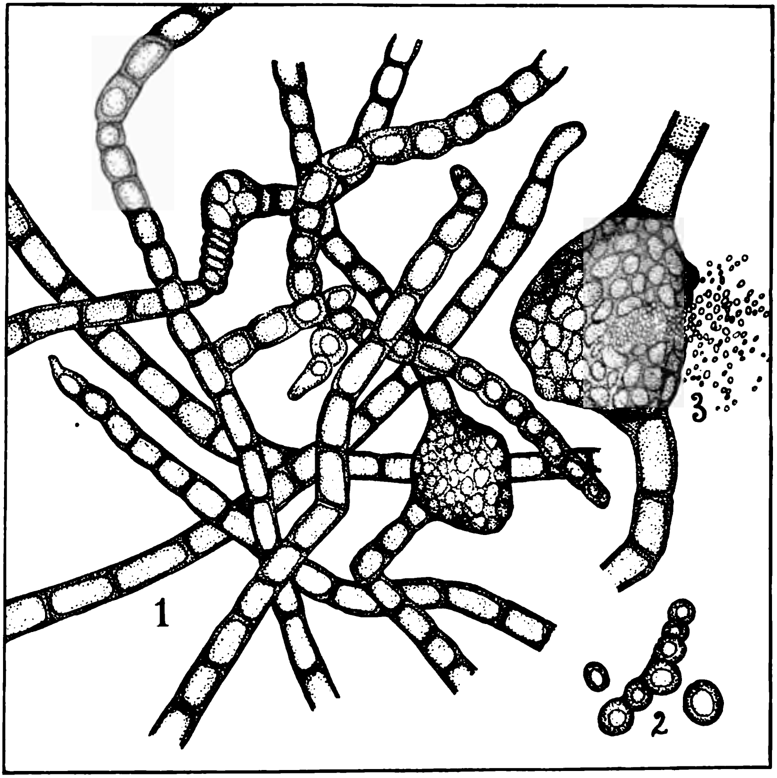
"The orange tree is so averse to much, and particularly fresh manure, that penning or fattening cattle or horses among them, the passage of foul gutters near them, or the frequent use of the wash-tub under their shade, soon produce disease and death; consequently low, rich soils, and abundant manuring are not favorable to the growth or quality of the sweet orange."—*The Southern Farmer and Market Gardener, Francis S. Holmes. Page 104. 1852.*

Quite a number of growers have experimented with Bordeaux mixture as a cure for die-back and report that benefit has been derived from the application of that compound, even where no alteration was made in the fertilizer. On February 22, 1900, a number of trees were examined in a young grove belonging to Mr. Harrington, of Winter Haven, Fla. These trees had been very badly affected with the disease and were sprayed about September 1, 1899, and again January 1, 1900. The mixture first applied was quite strong, six to twenty-two; the second, four to twenty-two. The leaves, young growth and flower buds were uninjured by the second application. Since the first treatment the trees, in many cases, made an apparently healthy, new growth of nearly two feet. No new growth had survived for months before. Whether we are to regard Bordeaux mixture as a remedy is yet in doubt, but it is worthy of a trial. Better to use a one to ten solution.

SOOTY MOLD.

Sooty mold, *Meliola Camelliœ* (*Catt.*) *Sacc*, is widely distributed throughout the State. It occurs as a sooty-black covering on the leaves, fruits, and twigs of many plants, and is intimately associated with various insects belonging to the families *Aleyrodidœ, Coccidœ and Aphididœ.* In Florida it follows *Lecanium oleœ* on *Nerium oleander* and *Persea Carolinensis; Aphis gossypii* on the orange, egg-plant, and many other herbs, shrubs, and trees; *Lecanium hesperidium, Ceroplostes Floridensis* and *Aleyrodes citri* on the orange. In short, it may be said that it is found with all the scale and allied insects which exude honey-dew in any considerable quantities.

The fungus is a saprophyte, and is dependent upon this honey-dew for its sustenance. The insects already referred to are gregarious in their habits. Consequently, the honey-dew accumulates in considerable quantities on various parts of the plant, and in this substance the fungus lives. The black covering is composed of its vegetative threads. A number of different kinds of reproductive bodies are produced, and, through the agency of the wind, are carried about from tree to tree. Wherever suitable food material is found, there the fungus develops.



Cut. 2.

Sooty mold (greatly enlarged). 1. Mycelium or fungal threads; 2. Conidia; 3. Pycnidia with immature spores. (Drawing by Miss L. McCulloch.)

It is when it follows the attacks of the white-fly or mealy-wing, *Aleyrodes citri*, that the fungus most frequently causes damage in the orange groves. This insect spends a great portion of its life on the under side of the leaves. The honey-dew exuded by it, falls upon the upper sides of the leaves beneath, and upon the twigs and fruit. Whole groves are to be seen in the State to-day, the trees in which have their leaves completely covered by *Meliola.* The trees from a distance appear as though they had been coated with a liberal application of stove-black.

Sunlight is necessary to the leaves of a tree in order that they may carry out their work in the plant's economy. The black screen of fungal threads prevents the light from reaching the leaves. Their natural functions are interfered with and the tendency is to keep the tree in an unhealthy condition. Often the yield of bearing trees is greatly lessened as a direct consequence.

However, the immediate damage is to the crop. The stem end of the fruit becomes covered by the mold; it colors irregularly and is often unfit for market. Various methods are used to remove the sooty covering from the oranges. Some use a lidless box. Over the open side, a piece of coarse sack-cloth or canvas is stretched and on this cross-cut sawdust is scattered. The oranges, one or two at a time, are taken and ground about on this until the soot is removed. Another machine consists of a hollow clinder, mounted on stationary posts, and having a crank attachment. This is partially filled with oranges and sawdust and revolved until the fruit is bright. Washing with a cloth or brush is also resorted to, and some simply use a dry brush. Often, however, the oranges appear on the market with the mark of mold upon them. This is particularly the case if the fruit is in any wise rough-skinned, the fungal threads still remaining in the depressions.

The additional cost of harvesting and marketing a crop of oranges is very considerably increased and the fruit can not help but suffer to some extent from the harsh treatment it often receives. Oranges have been noticed which had been so vigorously cleaned that the epidermis had been torn and the oil-glands of the rind laid open. This, together with the injury occasioned by bumping the fruit about, is certain to impair the keeping qualities.

Remedies.—These consist of such treatments as will destroy the white-fly ; that accomplished, the sooty mold no longer having food in which to develop, will disappear.

There are certain natural agencies at work, which tend to keep the *Aleyrodes* in check. Professor Webber* made an exhaustive study of these a few years ago, the results of which were published as a bulletin. *Aschersonia aleyrodis* Web., and the brown fungus are the ones which have attracted much attention, and were it not for these two fungi. the white-fly would cause much more injury than it does. The former is characterized by its pinkish or cream color and circular elevated form; the latter by the brownish, membranous covering that envelops the insect. In fact the red scale, *Aspidiotus ficus*, is sometimes mistaken for the white-fly covered with the brown fungus. Both these friends are no mean help against the white-fly, and from careful observations in a number of groves, the writer is inclined to place a very high estimate upon their work. But these natural agencies should not be depended upon entirely. It has been observed that the fly often has free scope in a grove for two or three years before the fungi get it under control, and the opinion is ventured that never until the matter is earnestly taken in hand by the growers, will the white-fly be controlled, and, even then, eternal vigilance will be the price of freedom from the pest. It is here to stay, and should receive more attention than it does.

This brings us to the question, "Shall I fumigate with hydrocyanic-acid gas or spray with kerosene emulsion or resin wash?" The main objection to spraying is that it is extremely difficult to reach every portion of the tree and this is more particularly difficult on account of the dense top that is usually left on the orange trees. In order to receive the full benefit from spraying, it would be necessary to open up the heads of many of the trees and other benefits would be derived as well. Every insect must be reached in order to destroy it. But, with sufficient care, the work may be so thoroughly done as to effectually check the insects for the time. Fumigation has, with many insects, proven to be the most efficacious method of treatment. Hydrocyanic-acid gas is extremely deadly to nearly all adult forms of insect life. and it has proven to be so to the white-fly in the pupa state. It is only recently that this treatment has been given a trial in Florida by the Experiment Station. Work has been undertaken, and will continue under the supervision of Prof. Gossard,* the Station Entomologist, and since the solution of the problem relating to the destruction of insect life by these means belongs more properly to his department, we shall look to him for further information.

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*Sooty Mold of the Orange and Its Treatment. Bul. Div. Phy. and Path. U. S. D. A., 13, 1897.

Resin wash:

20 lbs. resin, 3 1-2 lbs. 98 per cent. caustic soda, 2 1-2 pints fish oil.

Place the three ingredients in a large kettle and pour over them about twenty gallons of water. Boil for two or three hours and gradually increase the amount to fifty gallons by the addition of wash. For use add 100 gallons of water, or if a small portion is required, preserve the same proportions. Stir thoroughly before removing any from the stock solution.

"Coccidæcide," a resin compound manufactured by E. Bean, Jacksonville, Florida, has been very successfully used by many growers in place of resin wash. This preparation is no longer on the market, but it is likely that those who desire to use it will be able to procure it before the end of the year.

Kerosene Emulsion.

Hard or whale-oil soap 5 lbs., water 10 gallons, kerosene 20 gallons.

Shave the soap into small pieces and dissolve in ten gallons of boiling water. Remove a distance from the fire, and while still boiling hot, add twenty gallons of kerosene. Mix with a spray pump, forcing it back into itself a number of times.

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*Fumigation for White-Fly and Rust Mites, Semi-Weekly Times-Union and Citizen, March 2, 1900.

Spray with either resin wash or kerosene emulsion several times during the dormant season. The spray should be directed so as to strike the lower sides of the leaves.

Fumigation:

Potassium cyanide, water, commercial sulphuric acid.

The following amounts for different-sized trees are given as figured by Mr. J. Scott, horticultural commissioner of Los Angeles, California:

Height of tree (feet).	Diameter through foliage (feet).	Water (fluid ounces).	Sulphuric acid (fluid ounces).	Cyanide potassium (ounces).
6	4	1	½	½
8	6	2½	1¼	1¼
10	8	3½	2	2
12	10	6	3	3
12	14	9	4½	4½
14	14	10	5	5
16	16	12	5½	5½
18	16	12	6	6
20	16	13	6½	6½
22	18	15	7¼	7¼
24	20	16	8	8
26	20	16½	8¼	8¼
30	20	17½	8½	8½

The tree is covered with a tent, the chemicals are placed beneath and left for forty minutes. A glass or earthenware container is used, and when in position beneath one side of the tent the water is placed in the vessel first, then the acid, and last the cyanide of potassium is quickly dropped in, the tent being lowered immediately. If the tents are used during the day, they must be painted black, as the sunlight acts injuriously in helping to scald the leaves. The trees should be as free as possible from moisture, as water is capable of absorbing large quantities of the gas, and beneath drops of water the insects are uninjured. It should be borne in mind that hydrocyanic-acid gas is extremely poisonous.

To give a rough idea of the cost of the tents and chemicals required in fumigation, the following excerpt from a letter received from Mr. C. P. Fuller, of Ellenton, Fla., is inserted: "The sulphuric acid costs in New York 2 cents per pound, and the carboy costs $1.75. When empty, the carboys can be returned at cost, less freight returning.

The cyanide of potassium costs 32½ cents per pound in New York. The freight on both of the above articles is very high, 2 cents per pound or more. As I ordered my tarpaulins hurriedly, I got them ready made from Montgomery Ward & Co. of Chicago. I think it would be better to have some made of an octagon shape.

I paid in Chicago:

18x20	feet tarpaulins.	$5.50	each	Single filled 8 oz. duck.
20x24	" "	7.10	"	
20x40	" "	11.80	"	
24x50	" "	17.70	"	

You will have to add to these prices the cost of oiling, which is 20 to 30 per cent. of the cost of material, unless you use the cactus juice."

BLIGHT.

Blight is the most dreaded of all the citrus diseases in Florida. When it was first noticed is not definitely known, but it has been a source of trouble in the orange groves for a number of years. Many of the groves in which it once worked havoc have disappeared, having been frozen out. Previous to 1895, it became so prevalent that it threatened totally to destroy the citrus industry in certain districts, and, at the urgent request of the State Horticultural Society, agents were sent to Florida by the Agricultural Department. Prof. L. M. Underwood made a trip through the State in order to find what were the chief questions to be investigated. In 1891, Dr. Erwin F. Smith studied the disease for some time, and later Professors Webber and Swingle were stationed in the section where blight was prevalent.

Though many of the affected groves were cut off in the great freeze, still it is to be found in the State, blighted trees having recently been found in three different localities. Thus far in no one of them had it caused any serious damage, but its further effects are to be feared, because, so far as known, it is incurable.

Blighted trees appear as though suffering from drought, or in a manner similar to ones recently set out. The leaves wilt, and droop and finally drop off. In some cases the disease works very rapidly, in others its progress is decidedly slow. It often manifests itself on a single branch and from that gradually spreads over the whole tree. Trees affected in this way live for a considerable length of time. On the other hand, it may act very rapidly; for instance, on one tree the disease commenced in a definite area on one side of the top and quickly spread both ways round the head, meeting on the opposite side. The tree in this case quickly succumbed. Usually, however, new shoots are put out, which grow well for a time, but later yield to the disease.

Up to this time the cause of blight remains unknown. It appears among old bearing trees, which are well cared for in every way, and which up to the time of attack are apparently in perfect health; therefore, it can not be assigned to any external cause.

Remedies.—The key to the successful treatment of any plant disorder is to know the cause and nature of the ailment. This has not yet been found. Furthermore, my observations have gone to confirm those of others, that the disease is likely to spread from one tree to another. Trees once affected rarely, if ever, survive, and the best treatment is to dig out and burn the affected ones and place others in their stead. This is the most economical plan as well, because affected trees never repay the time and trouble taken with them.

MELANOSE.

This disease* was first described by Swingle and Webber and given the above name in 1896. It was at that time found on trees in the region of Citra and to some extent in other parts to the south of that place. This season it has been collected in several places in south Florida, but only in one locality was the disease prevalent, and two groves composed of sweet oranges, tangarines and pomeloes were badly affected.

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*It has also been reported from Australia. Dr. Cobb Ag. Gaz. New South Wales, 8. IV 225.

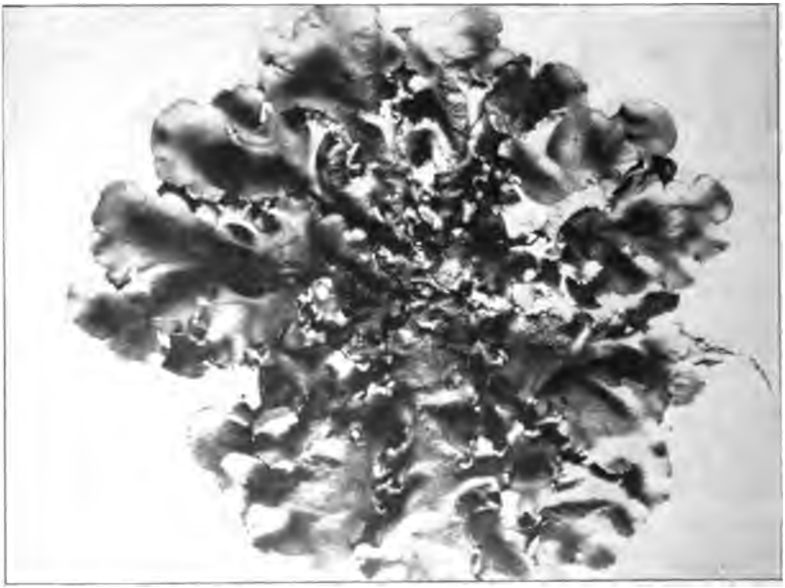
On the leaves, fruit, and twigs of affected trees small brownish-black spots are to be seen. These spots are sometimes separate and sometimes confluent. Where separate, the intervening tissue is apparently quite normal, but where confluent to any considerable extent, a brownish tinge is given to the whole leaf. The spots are somewhat elevated and are occasionally found to be cracked or fissured at the apex. This is true when on the leaves as well as when on the fruit. Under diseased trees large numbers of leaves are found, showing to what extent the disease has been injurious. The disorder causes damage to the trees by defoliating them, rendering the leaves unable to carry out assimilative processes for quite a time before they drop, and also in rendering the fruit unsightly, because of the irregular dark-colored areas which cover the surface.

Careful microscopical examination has been made of the diseased spots, but nothing has been found to which the trouble might be attributed. It has been suggested that it may be caused by some vegetable organism, but thus far nothing has been found to establish this fact beyond the observation that the disease seems to spread from tree to tree, and the fact that it yields to applications of fungicides.

Remedies.—Experiments have shown that this trouble may be controlled by the use of Bordeaux mixture in very weak solution, one to twelve and one-half or fifteen used as a preventive, not as a curative. The dangerous period to the fruit is while it is still young. It would be best to commence spraying during the dormant period, before the trees bloom, and spray once a month until the fruit is well formed; that is, about the month of July.

LICHENS.

These plants are found growing upon stones, logs, boards, fences, and living trees throughout the country. In color they are yellow, green, reddish, or gray. Their forms are many and varied; some adhere closely to the substance on which they grow (crustaceous); some are branched and elevated (fruticose); while others present a rough, crumpled surface (foliaceous). From the botanist's standpoint, lichens are among the most interesting members of the vegetable kingdom; they consist of a fungus and an alga growing together, each contributing to the welfare of the other (symbiosis). The fungus furnishes water containing food in solution and shades the alga, which, in return for these good offices, supplies the former with the results of its assimilative processes.



Cut 3.

A Foliaceous Lichen, Parmelia perlata (L.) Ach.

The moist, warm climate of Florida is an ideal one for their development. In many orange groves the trunks and larger branches of the trees are covered with lichens; they are obnoxious to the eye, and to a certain degree detrimental to the health of the tree. They are not parasitic, but they prevent a free interchange of gases through the bark, thus, to some extent, producing a condition detrimental to the health of the tree; and certain it is, they are never so plentiful on healthy, vigorous trees as upon those which are in poor condition. They serve also as a harborage for insects and insect eggs.

Consequently, it is very desirable that the trunks of the trees should be kept free from lichens, and, fortunately, this is easily accomplished at a very slight cost. One treatment, every two or three years, will be sufficient to keep the trunks in a clean, healthy condition.

Remedies.—Lichens may be destroyed by spraying with Bordeaux mixture. On the experimental grounds at Lake City, three pear trees were thoroughly sprayed, January 17, with a strong solution of Bordeaux, six pounds copper sulphate, and four pounds lime to twenty gallons of water. In a very few minutes the effect was noticeable, the gray lichens having turned yellowish in color. The trees were examined from time to time, and at the date of writing all lichens are dead, and in most places the foliaceous varieties have been partially removed from the trees by the action of the rain. In applying such a strong mixture to the trunks of orange trees, care should be exercised that the spray be kept as much as possible from young foliage, and the better plan would be to follow the method adopted by Prof. M. B. Waite* and apply the mixture with a whitewash brush.

The following solution can also be highly recommended:

Hard soap, crude carbolic acid and *water.*

Dissolve four pounds of soap in ten gallons of water by boiling, and while still hot, add four pints of crude carbolic acid. Apply with a palmetto brush.

LEAF SPOT.

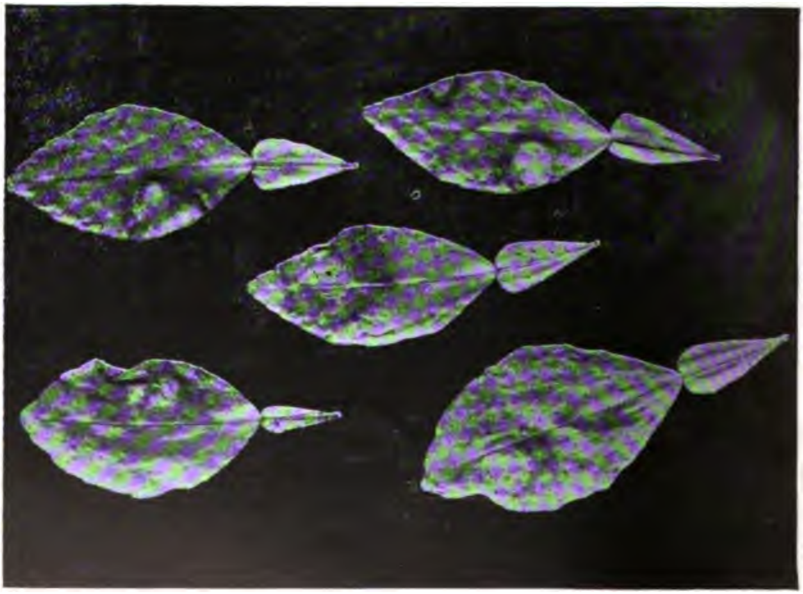
Orange leaves affected by this disease were collected in Florida at Green Cove Springs by Dr. Martin in 1886. Later it was referred to by Prof. L. M. Underwood[1] in 1891 as being slightly injurious to orange leaves in Lake County, Florida. This year it has been collected at several points in the State and some damage has been done by it to the foliage of citrus trees. In one case a number of pomelo seedlings were found which were almost defoliated in consequence of their being attacked by this pest.

---

* Waite, M. B. Experiments with the Fungicides in the Removal of Lichens from Pear Trees. Jour Myc., 7: 264-268. *Pl. 30, 31.* 1893.

[1] Underwood, L. M. Leaf Spot (of Orange). Jour. Myc., 7, 34-35.

Large, somewhat circular, yellowish spots are noticed on the leaves. Close examination reveals the presence of minute dark dots scattered thickly over the discolored areas. These small, dark spots contain the spores of a parasitic fungus, which is the cause of the trouble. The sporules are borne on short filaments which are contained in the brownish-black conceptacles. Plate No. 6 shows some of these conidia and basidia, together with germinating spores, all greatly enlarged.



Cut 4.

Leaves of Pomelo Affected by Leaf-Spot Fungus, Showing Characteristic Rounded Spots.

This fungus has been known under two different names. It was described as *Phyllosticta adusta* E. & M.[2] from the specimens collected by Dr. Martin. Later it was referred to the genus *Colletotrichum* and named *C. adustum* E.[3] It appears, however, to be identical with *Colletotrichum glœosporioides* Penz.[4]

---

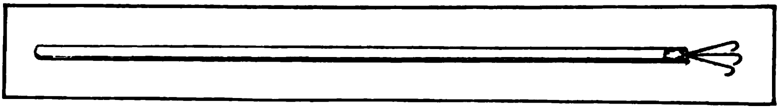
[2] Jour. Myc., 2, 130.

Remedies.—Apply ammoniacal solution or Bordeaux mixture.

MOSS.

The plant, variously known as Moss, Gray Moss or Spanish Moss, *Tillandsia usneoides* L. often becomes a pest in orange groves. It is too well known to need description, though it might be stated here that it is not a moss, but is closely related to the pine-apple.

This plant is an epiphyte, dependent upon food received from the air and rain for its nourishment. It appears to interfere with the development of branches, leaves and fruit, and certainly prevents the free circulation of air. Trees of any kind, when densely covered with the *Tillandsia's* enveloping festoons, do not have the healthy, vigorous appearance of those which are free from it.



Cut 5.
Tool for Removing Tillandsia.

The only satisfactory method of removal from orange trees is to pull it off by hand. A tool, resembling the one shown in the cut, is of great assistance in removing moss from the tops of tall trees. The fork-like portion is made by taking three pieces of No. 6 or No. 8 wire and twisting them together to form a shank. The free ends, which are four inches long, are bent in a short curve about an inch from the end and given a spread of about four inches. The shank is then inserted in a handle of any convenient length. A light bamboo pole answers the purpose very nicely.

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[3] Jour. Myc., 7, 35.

[4] Id., Ellis.

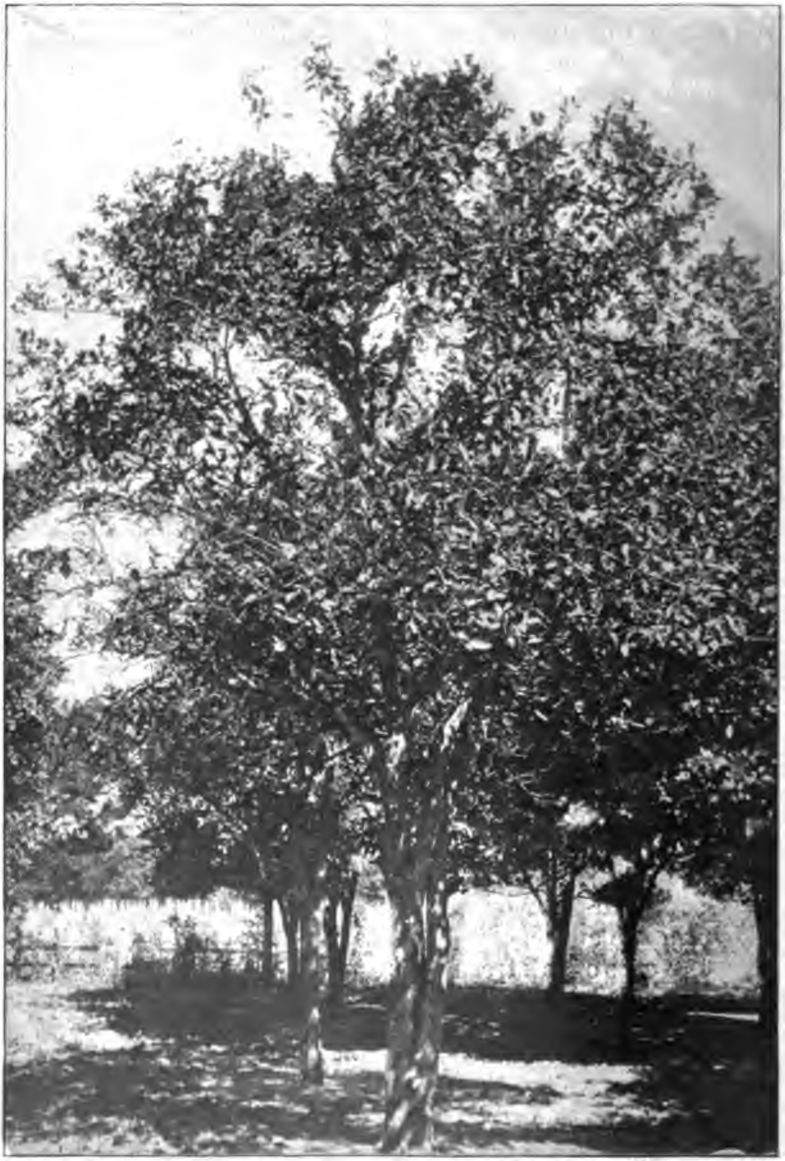

Plate I.
FOOT ROT OF THE ORANGE.

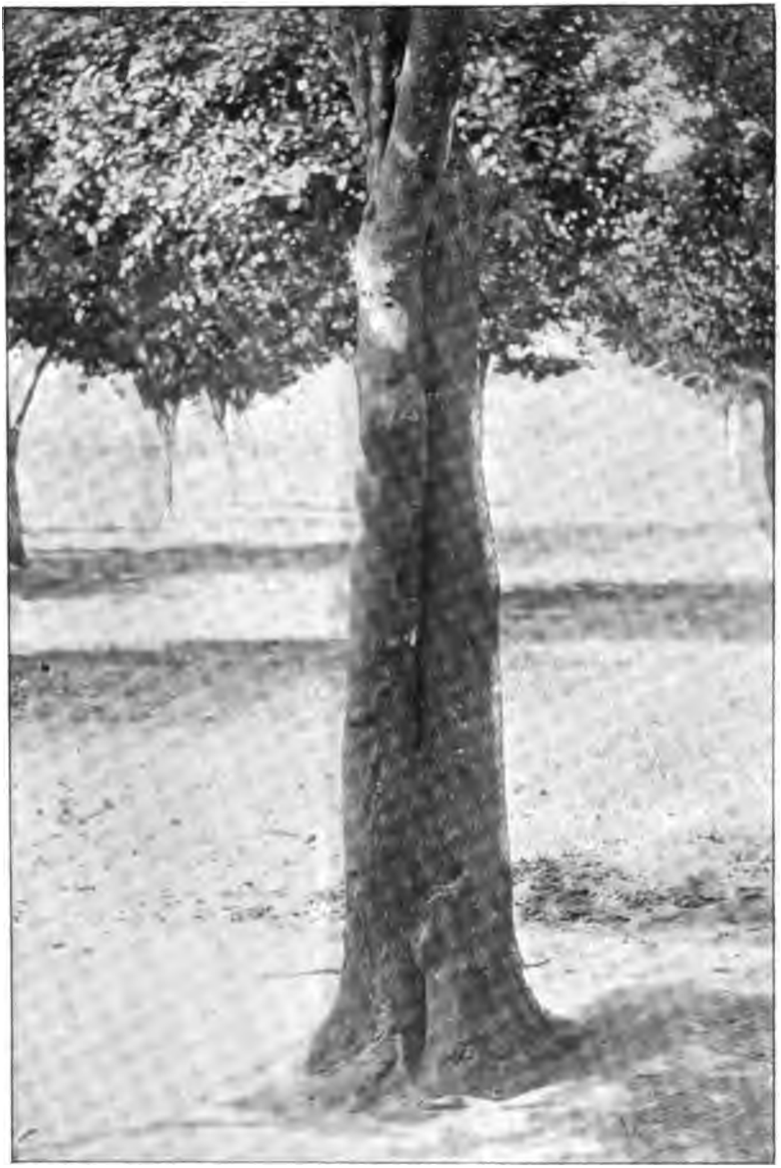

Plate II.
FOOT ROT OF THE ORANGE.

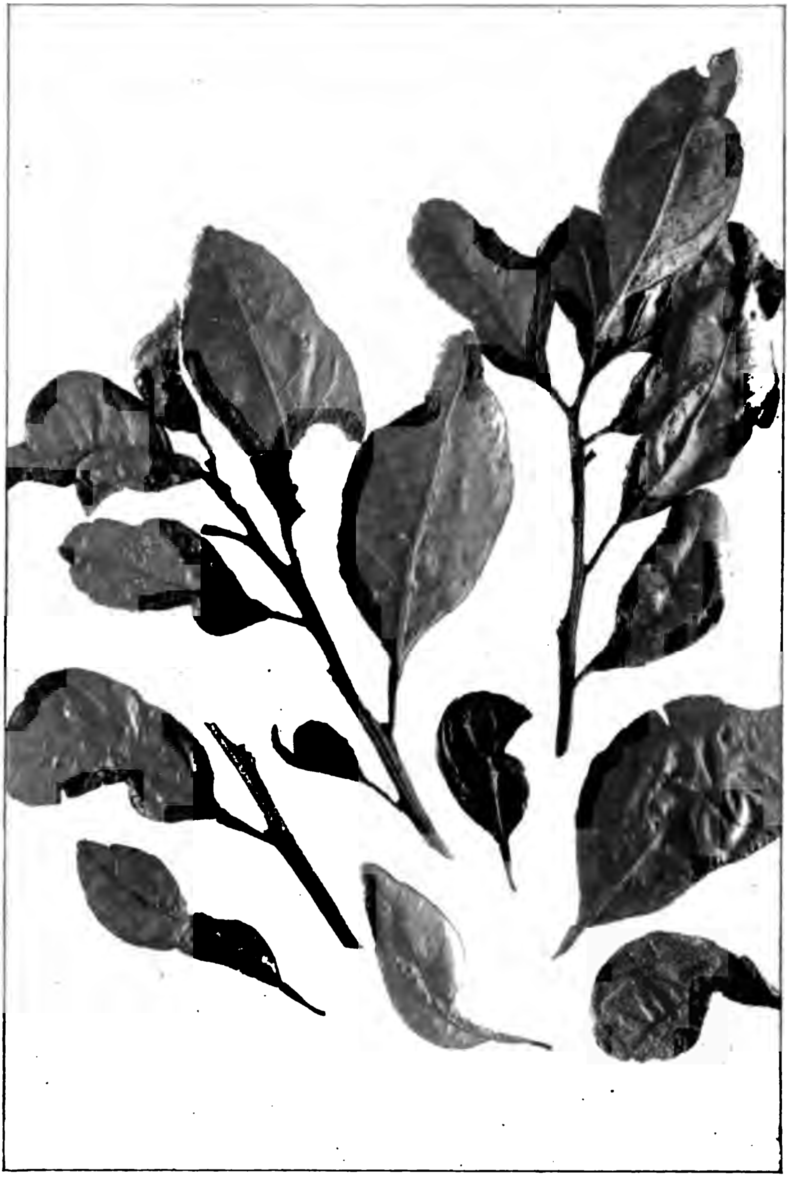

Plate III.
SCAB ON SATSUMA ORANGE LEAVES.

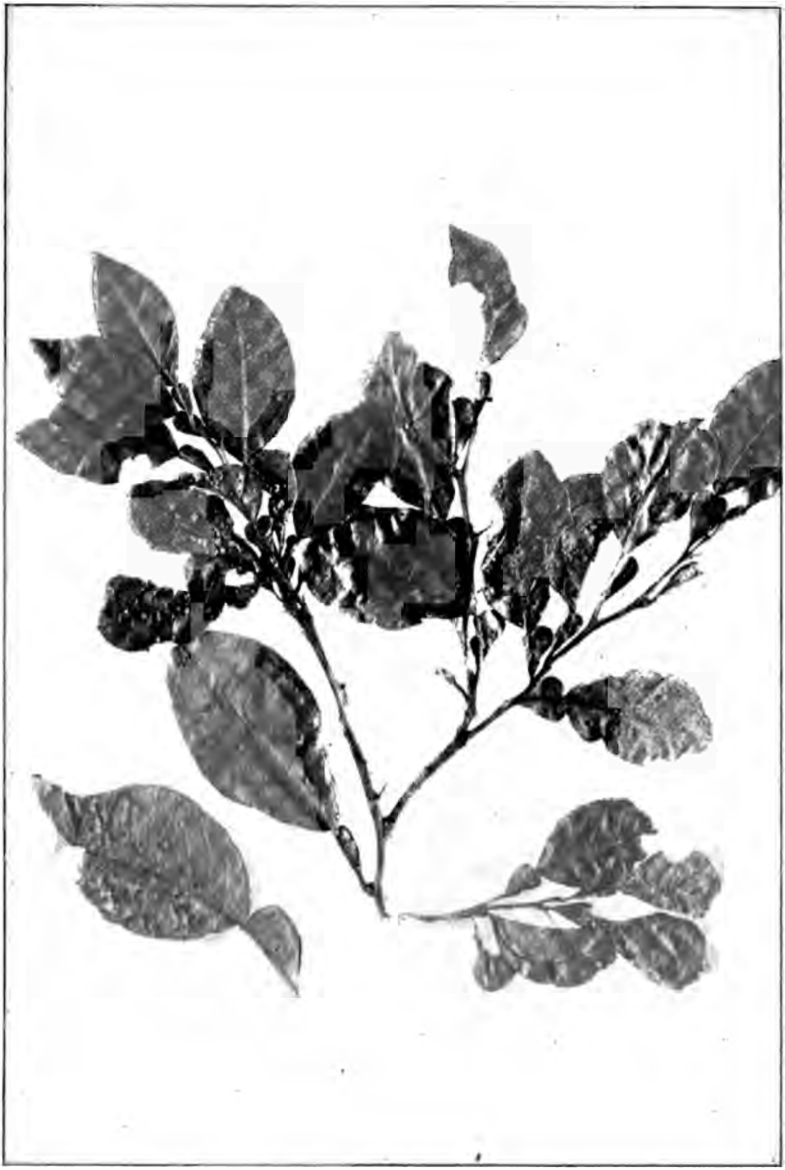

Plate IV.
SCAB ON SOUR ORANGE LEAVES.

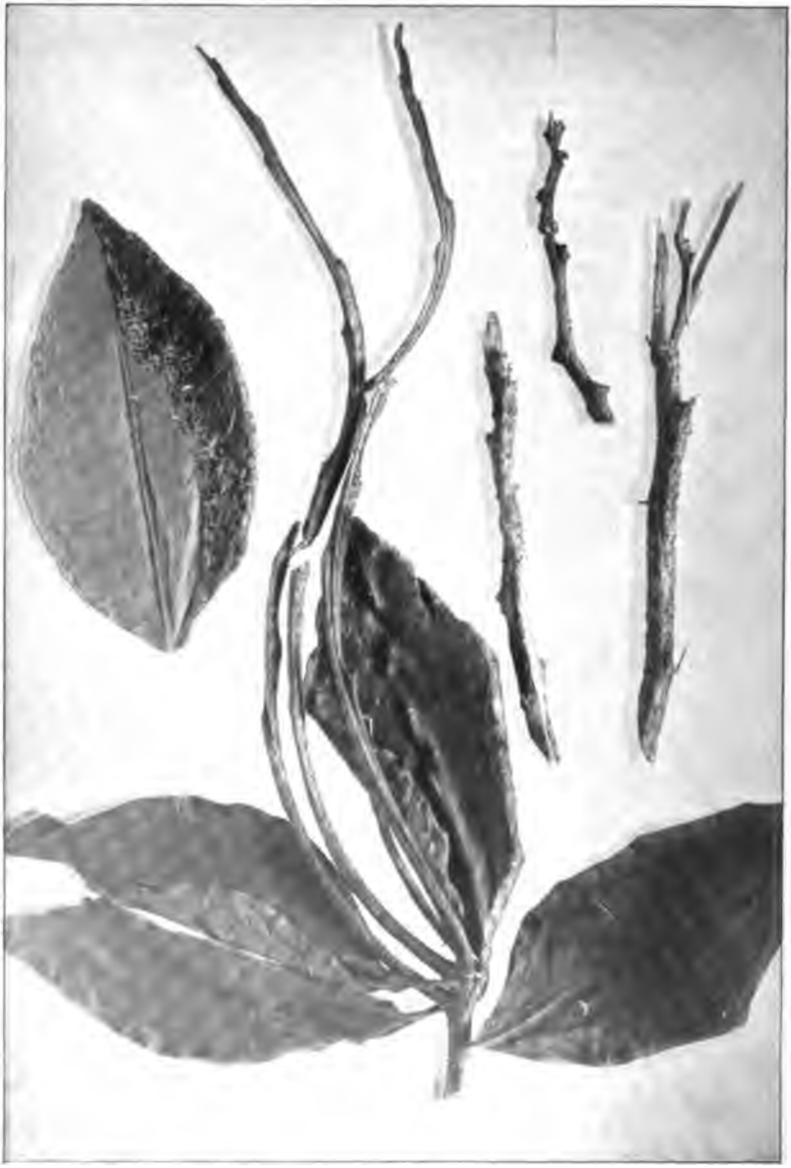

Plate V.
DIE-BACK OF THE ORANGE.

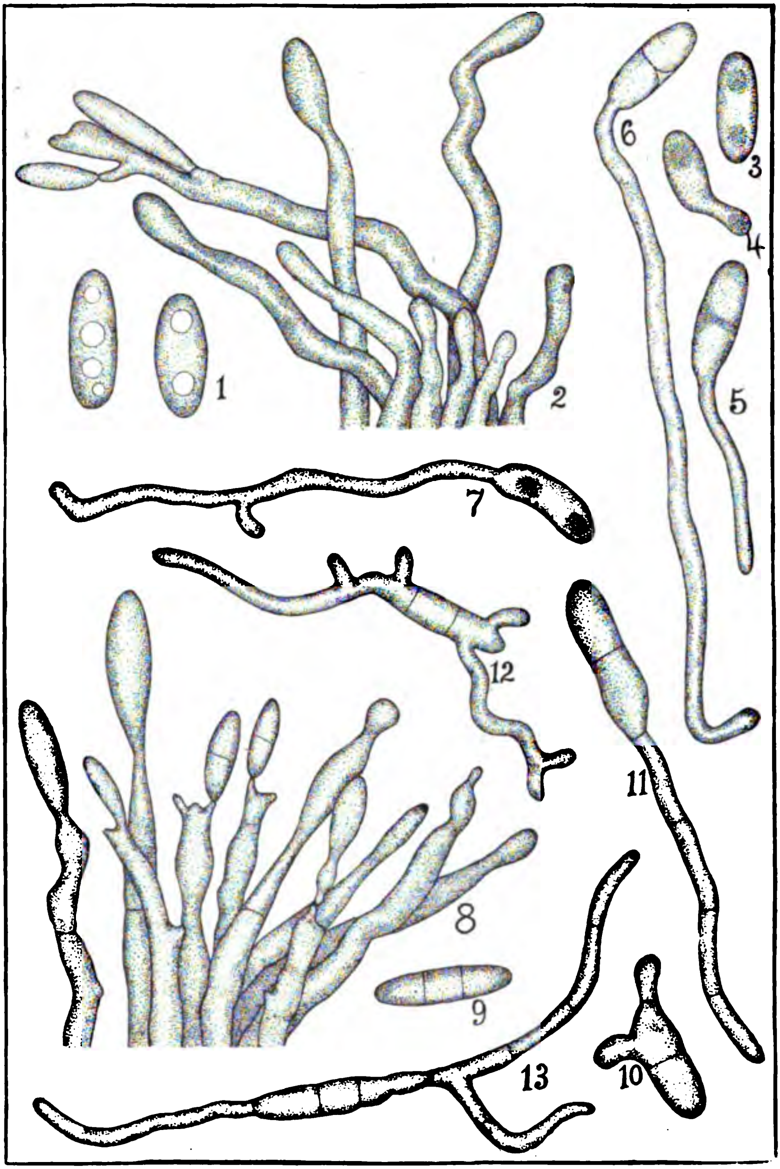

Plate VI.
FUNGI OF LEAF SPOT AND SCAB.

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BULLETIN No. 54. AUGUST 1900.

FLORIDA
AGRICULTURAL EXPERIMENT STATION.

PECAN CULTURE.

A PRELIMINARY REPORT.

By H. HAROLD HUME.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

1900.
THE H. & W. B. DREW COMPANY,
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THE PECAN.

INTRODUCTION.

The pecan is one of the best of our native nuts: in fact, as a desert nut, I am inclined to think it heads the list. Large quantities are grown in the Southern States every year, but the crop is by no means as large as can be grown profitably. In northern Florida to-day there are hundreds of acres of land on which the pecan can be grown successfully, and it is one of the grove crops which should receive more attention than is now bestowed upon it. True, there are many trees and groves scattered throughout the northern and western parts of the State, but the industry has by no means reached the limit of profitable production.

On the other hand, the pecan should not be boomed to the exclusion of other crops, neither is it advised that it be planted throughout the whole State; but, there is a vast area in which it could be grown to advantage. In the south, other horticultural crops can be and are grown: these should be continued. But in northern and western Florida, the pecan is as nearly reliable as any orchard tree generally is, and, considered from the standpoint of certain remuneration, it should be planted more extensively than at present.

When we consider the fact that more than two and a half million dollars' worth of nuts were imported into our country last year, it can readily be seen that there is still a large demand which may, to a very considerable extent, be met by a home product. Moreover, this demand is steadily increasing, and of nuts grown throughout our country to-day, whether native or introduced, none is more worthy of careful cultivation than the pecan.

It is only of late years that it has received the attention, as a cultivated tree, that it so well deserves, and at present most of the pecan nuts come from either Texas or Louisiana, usually the product of the native forest trees. As compared with other nuts, it ranks high in food value, and the kernel is particularly sweet and palatable. The following portion of a table, copied from Bul. No. 54 of the

Maine Ag. Exp. Sta., by Chas. D. Woods and L. H. Merrill, may be of interest:

	Edible Portion	EDIBLE PORTION.					Fuel Value per Pound*
		Water	Protein	Fat	Carbo-hydrates	Ash	
	%	%	%	%	%	%	Calories
Pecans, kernels....	100.0	2.9	10.3	70.8	14.3	1.7	3445
Walnuts, kernels...	100.0	2.8	16.7	64.4	14.8	1.3	3305
Filberts, kernels....	100.0	3.7	15.6	65.3	13.0	2.4	3290
Cocoanuts, shredded	....	3.5	6.3	57.3	31.6	1.3	3125
Almonds, kernels...	100.0	4.8	21.0	54.9	17.3	2.0	3030
Shelled peanuts....	100.0	1.6	30.5	49.2	16.2	2.5	2955

*Calculated from analysis.

RANGE AND SOILS.

The southern limit in successful culture in the State has been rather difficult to determine, as a positive statement could only be made after actually growing and fruiting the tree in Southern localities. Yet it has been ascertained that it extends well into the region within which orange culture may be successfully carried on under our present conditions. At Oneco, Fla., there is a large, symmetrical tree which Mr. Reasoner informed me bore annually full crops of nuts. I have seen thrifty trees at Bartow, and have been informed on reliable authority that fruit has been obtained from trees at Fort Meade.

The statement is generally made that the pecan will succeed wherever the larger species of hickory are found in the State, and this is doubtless true, as the pecan belongs to the same family of trees (*Juglandaceæ*) and to the same genus (*Carya*) as the hickory. Unfortunately, as yet, a systematical, botanical survey of Florida has not been made, and I am not aware of the exact range of the different varieties of hickory.

The peculiar conditions of soil and moisture surrounding the pecan in its native home might be regarded as an indication that it could not be grown except on deep, rich soil, in proximity to rivers, ponds or streams. Such, however, would be a wrong inference, for it succeeds admirably and bears good crops on a wide range of soils. Hence, we find it to-day in localities far removed from the regions to which it is indigenous, and thriving under conditions differing greatly from those obtaining in its native home. In Florida trees may be found growing on soils ranging from the black hammock to the less fertile high-pine lands. On hammock soils, however, the trees are often inclined to develop wood at the expense of fruit, while on less fertile soils the trees make less wood and bear more fruit proportionately. Pecans thrive well on flat woods, one of the best proofs of which is the Russell grove at Olustee, Fla. Moisture in sufficient quantity must be present. but it will not do to plant the pecan on land that is continually wet and soggy. The presence of a hard. impenetrable subsoil doubtless has a great influence upon the wellfare of the tree, and it would be better to select other ground, or, when this is impossible, to blast out the hardpan.

In relation to the question of soils, the following notes may be of interest: "I have purposely tried all kinds of soil—stiff black lands, in second river bottoms, subject to occasional overflow; sand-ridge with no clay subsoil; sandy loam with clay subsoil; chocolate soil; pebbly land with clay subsoil, and stiff clay land with but little top soil. I find the sandy loam with clay subsoil the best, black lands next (though black lands grow too much wood and do not fruit as well as some others). Pebbly lands come next. Those on clay lands bear well and early, but the nuts are small. Trees on the sand ridges are of slow growth and longer in coming into bearing than others, but bear very good nuts."
[G. M. Bacon, Dewitt, Georgia, in a letter dated November 28, 1899.]

"The sandy pine land will produce them to perfection."
[J. B. Ley, letter in the Florida Dispatch, October 4, 1886]

"The pecan will grow on any soil except, springy, boggy land where water stands near the surface, or where the soil is underlaid with ledge rock at a slight depth."
[R. E. Merryman. in an article in the Times-Union and Citizen, copied in the Florida Agriculturist, March 14, 1900]

"The pecan will thrive on dry land which is good for corn or cotton, and I can show trees on common pine land as large and thrifty for their age as any grown on high or hickory land."
[J. K. Russell, in Florida Life, copied in the Florida Farmer and Fruit-Grower, p. 828, 1893.]

PROPAGATION.

The pecan is propagated either from the nuts or by budding and grafting. The former was the plan generally adopted a few years ago, but it is gradually giving place to the usual methods employed in the propagation of fruit trees.

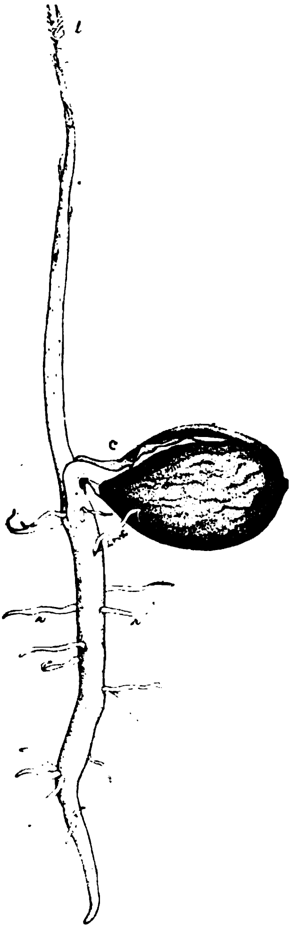

Fig. 1. Germination of the Pecan.
l. First leaves.
c. Cotyledons.
r. Rootlets.
(Drawing by Miss L. McCulloch.)

There are several decided objections to raising a grove from the seed by planting the nuts where the trees are to stand. Usually the ground is not so well prepared as when trees are planted, and such nuts as survive the attacks of mice, moles and ants, produce trees which have to make their growth under rather unfavorable circumstances. Many vacancies occur even when several nuts are planted in a hill, and the grove in consequence often presents a very irregular appearance.

If it is desired to raise a grove from seed, the very best selected nuts should be obtained, for it need scarcely be expected that more than fifty or sixty per cent of the trees (and in all probability less) will come true to the seed. Do not plant them in the field where the trees are to stand. Nuts of large or medium size and good quality are rather expensive, and, besides, better developed trees and more satisfactory results can be obtained by adopting the following plan: Thoroughly prepare a seed bed as for vegetable seeds; have the soil rich, deep, thoroughly pulverized and sufficiently moist, but well drained: in this bed plant the nuts in rows two and one-half feet apart, placing the nuts on their sides, three inches beneath the surface and four or five inches apart. They should be planted soon after they are ripe; after the trees have appeared the nursery should be cultivated from time to time, and fertilized as for other young trees, being careful to scatter the fertilizer down the center of the space between the rows. In this way the trees can be given much better and more economical care and attention than could be given had the nuts been planted in hills in the field.

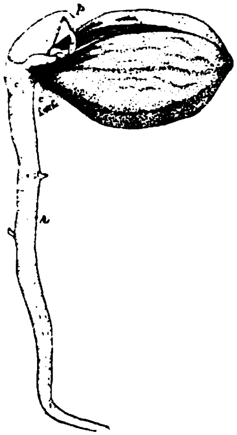

FIG. 2. Germination of the Pecan.
p. Plumule.
c. Cotyledons
r. Radical.
(Drawing by Miss L. McCulloch.)

In regard to the extent of variation in pecans raised from seed there is a great diversity of opinion. Writers place the amount of variation somewhere between fifty and one hundred per cent, but whether these conclusions are based upon actual observations or not I am unable to say. There is doubtless as much tendency toward variation as is found in other fruits. Some seedling trees may produce better nuts than those from which they originated, but there is just as great a likelihood that the reverse may be true, to the disappointment of the owner. True, we may have a fixed type, which will bear true to seed, but, generally speaking, two factors have to be considered—the innate tendency toward variation, and the fact that the seed represents the union of two elements.

Trees true to variety can not be obtained with certainty from the nuts, and we must resort to budding or grafting to secure them. Various species of hickory other than the pecan have been used as stocks, but by many the pecan is considered the most satisfactory. The methods adopted are usually annular, and veneer shield-budding, or cleft and whip grafting. I have given an illustration of veneer shield-budding. It possesses one advantage over the annular method, in that if the bud does not take the portion of the tree above the point of insertion is not lost. A plan highly recommended by Mr. W. H. Raynes, of Tallahassee, I give in his own words, and the plan might be modified by using scions from bearing trees: "I have tried both budding and grafting on the wild hickory, but nothing succeeds better than planting a common pecan and one of the big paper shells close together, having them marked so that there can be no mistake between the two nuts. I let each grow for two years, then I take the scion off the paper shell before it has put out in the

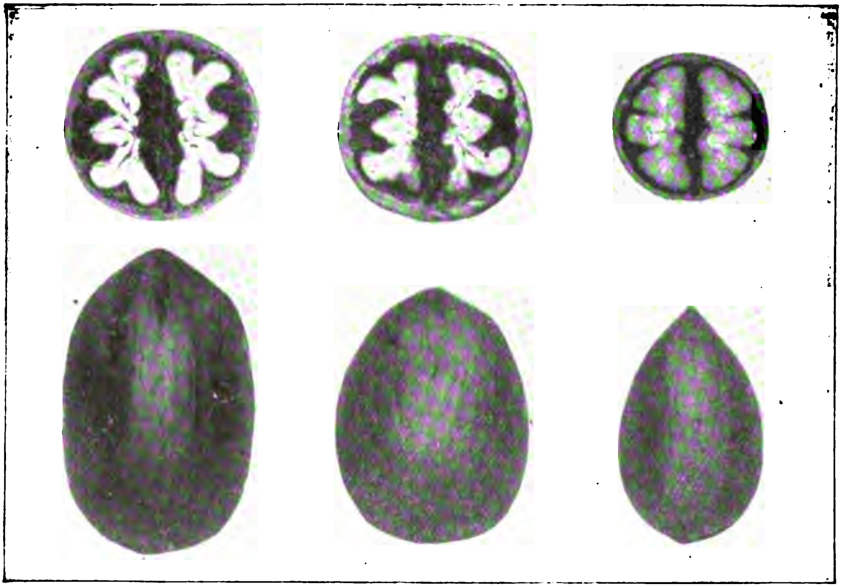

FIG. 3. Variation in Seedling Pecans: Frotcher Pecan on Left and two Seedlings from it, showing Variation in Thickness of Shell, Size, etc. (Natural size.) "From Webber & Bessey. United States Department of Agriculture."

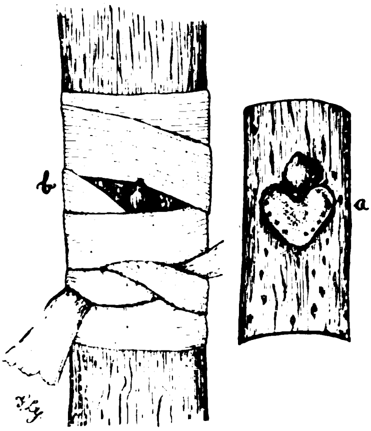

FIG. 4. Veneer Shield-Budding
a. Bud cut.
b. Bud inserted and tied.
(Drawing by Miss G. L Yocum.)

spring, and keep it in moist sand. Then I wait until the common stock has plenty of sap and is putting out leaves. Then I clear away the ground from the crown of the root and make an oblique cut from the crown upward, and a similar cut on the paper shell. Both cuts should be square and level. Then I get some grey moss and mix it with clay: I take a piece about the size of my fist and knead it well about the scion and stock and heap the earth over the stock. Three buds should be left on the scion, and the oblique cut should be from one-half to one inch in length. I am sure that you will have success."

There is no doubt that the pecan is extremely hard to work, and only when the budding or grafting is done by an experienced hand is it likely that good results will be obtained. However, despite the obstacles, which account for the rather high price at which the trees are sold, our nurserymen have usually a fair stock of budded or grafted trees on hand.

PLANTING.

Too often but slight attention is given to this important piece of work. There is too frequently a disposition on the part of the person setting trees of any kind to do the work as rapidly as possible without consideration for the future welfare of the plants. Few realize that time spent in careful, intelligent preparation of the soil and in setting the trees is time well spent, and well paid for in the after development of trunk and branch. Better a month spent in preparing the future home of the young tree, than years of its life spent in an unequal struggle for existence. More than that, the tree may die outright, and a year must elapse before it can be replaced. It is generally stated that the pecan is a slow grower, and yet I have seen trees from twelve to fourteen years old which measured from thirty-five to fifty-seven inches in circumference at the base, while under less favorable circumstances others stood still for a period of six or seven years, or until they had accumulated sufficient energy to overcome the untoward conditions of their environment.

The necessary preparation will depend largely upon the use to which the ground selected has been put previously. If some farm crop, such as cotton, cassava, cane or velvet beans, or horticultural crop, such as tomatoes, melons or eggplants, has been grown during the previous season, the ground will be in good condition to plant out at once. If it is desired to use a piece of pasture land, it would be preferable to break it up, fertilize, and plant some crop before setting out the trees. However, in the latter case, strips might be cultivated along the rows where the trees are to stand, and these strips later on gradually widened so as to embrace the whole surface. If a deadening is selected, all the fallen timber, logs and stumps should be removed from the whole field, or, to economise time or money, the same plan might be adopted as suggested for pasture ground.

Having selected the ground and prepared the surface, the next work is to stake off the ground. The distance apart for planting the trees has been variously given at 40, 50, 60, or even 100 feet. Forty feet I believe to be quite sufficient for most of our Florida soils, and that such distance will certainly be quite ample for thirty-five or forty years, and even longer. If the triangular method, as shown in the accompanying cut, be adopted, forty trees forty feet apart can be planted on a square acre.

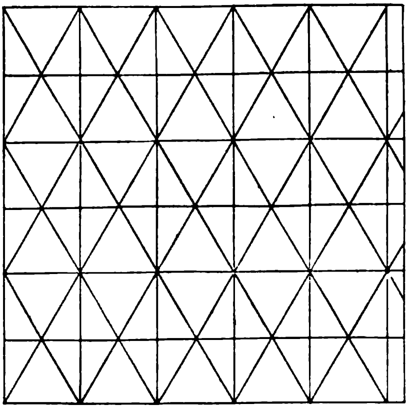

FIG. 5. Triangular Method of Tree Planting, showing number of trees which can be placed on a square acre.
(Drawing by Miss G. L. Yocum.)

To stake off the ground, commence on one side of the field selected, and plant stakes forty feet apart where the trees are to stand. Using two chains, or two pieces of rope, forty feet in length, the positions for the next row of trees may easily be ascertained by attaching the ropes to adjoining pairs of stakes, and stretching them taut to form with the base line an equilateral triangle. Plant a stake at the apex, then using the second row of stakes as a base line, repeat the operation. When the whole field has been staked off, the places where the trees are to stand should be thoroughly prepared. If the soil is very poor it would be particularly desirable to fertilize, and I believe it to be advisable in any case. A hole three or four feet across and nearly as many feet deep should be dug. With the soil thus removed, thoroughly mix a pound or a pound and a half of some good commercial fertilizer, and replace the soil, mounding it up slightly. This should be done two or three weeks before the time of planting. This accomplished, the remainder of the work of planting is a very simple matter. With a sharp stick make a hole in the center of the mound as deep as the root of the tree is long, place the tree in position, and pack the earth firmly about it. Care should be taken that the earth is brought in close contact with the root all the way down. A surface mulch of leaves, straw, or trash should be provided to prevent evaporation, or the ground frequently stirred to provide a mulch of dry earth.

The time of planting should be some time between the first of December, or latter part of November, and the first of March, giving preference to the earlier part of the season, as the soil will then have a chance to become firmly packed.

Pecan trees should be planted out in permanent grove when one or two years old. If budded or grafted trees are planted, the stocks will usually be three years old, as they are generally worked at two years. They can, of course, be transplanted when older, but it is more difficult to get them to live. Never allow the roots to become dried out. It is best that the necessary root-pruning be done in the shed, and that the trees be carried to the field wrapped in a damp blanket, from which they are removed as required for planting.

CULTIVATION.

Because the pecan grows as a forest tree in some parts of the country, it should not be supposed that, when once planted out, it should be left to itself. It will repay care and cultivation as well as any other fruit tree. Two plans have been adopted in cultivation, both of which give good satisfaction. The first is a system of clean cultivation from March until July, followed by a cover crop, such as beggar weed, cow peas, or velvet beans. This plan might be carried out until the trees are six or seven years old, when the grove may be seeded to grass and used as a pasture. It should, however, be fertilized once or twice a year, and it would be preferable to keep the grass cleaned away from the surface immediately surrounding the trees. The other plan is to use the ground between the rows for the growing of cotton, velvet beans, melons, or some other crop. The cultivated area will necessarily become more restricted each year, and eventually the ground will have to be given up to the trees. If a crop is grown, the fertilizing of the grove will consist in applying more fertilizer than the crop will take up.

"Cotton-seed meal is good for growing trees, but bearing trees will require some potash in addition to the meal."—*R. E. Merryman.*

"I cultivate all around my trees, and it really seems to do them good instead of injury. Florida does produce as fine pecans as are raised in the world." "I have pecan trees from thirty to forty years old that yield annually from 125 to 500 pounds without fertilizers of any kind, except oyster shells placed around them a year or so ago."—*Arthur Brown, Bagdad, Florida.*

PURNING.

ROOT–TRIMMING AND PRUNING.

When two years old a pecan tree will have from twelve to eighteen inches of top and from thirty to forty inches of root. Before planting, the tap-root should be cut fifteen or eighteen inches from the crown, or back to solid wood, and the small injured roots removed. The same should be done, proportionately, with one and three year old trees if they are set.

It appears to me that it would be an excellent practice on the part of our nurserymen to root-prune the pecan trees in the nursery row. I would suggest that this be done in the fall, after the trees are one year old. It could easily be accomplished by running the tree-digger down the row at a depth of nine or ten inches. The tap-roots would thus be severed, and the following spring the trees could be worked. This course of treatment would insure greater success in transplanting, as it would have a tendency to develop the lateral roots; and, in addition to that, it would, in all probability, induce earlier fruiting.

The statement that the tap-root of the pecan should be left intact is perhaps one of the reasons why this valuable tree has not been more extensively planted. Is it not high time that this horticultural superstition be laid aside with the many which have already given way to common sense and reason? Were it not that it seems to be so deeply rooted in the minds of many people, I should pass it over.

Two reasons have been advanced why this practice should not be adopted. The first of these is that the tap-root is necessary to hold the tree in its place that it may not be overwhelmed by the wind. Again, this large underground development is natural to the pecan, and, when once removed or injured, the tree, according to some, would never bear at all, or only indifferently, according to others, and from that time on the tree would be useless, except as an ornamental or as a shade tree.

The accompanying figure shows two pecan trees at two years. The one on the right was carefully lifted so as to preserve as much as possible of the tap-root, while the one on the left had the tap-root cut when it was transplanted at one year. In the former, six small roots from four and one-half to eight inches in length had grown out to replace the tap-root, these doubtless having supplied the tree with as much nourishment as would have been given by its own tap-root. Furthermore, without doubt, one of these roots would have grown so as to replace the tap-root. When the tap-root is cut, as is indicated in the figure, there need be no fear that the tree will suffer in any way because of the removal. The Stuart Pecan Co., of Ocean Springs, Mississippi, says: "Four hundred taken up out of our nursery and set out one year ago, and then taken up to sell, show there is not a failure to record. Every one of them has made a new tap-root."

Turning to the question of fruit production, it is found that the cutting of the tap-root produces no injurious effects. In fact, it is altogether likely that the cutting of the tap-root brings the tree into bearing earlier, and in nowise has it any detrimental effect either on its productiveness or its general health. Mr. Bacon's bearing groves at DeWitt, Georgia, are now twelve, thirteen and fourteen years old. The tap-roots of all the trees were cut at a distance of from twelve to fifteen inches from the crown when set out. There is certainly no reason to complain of the quality of nuts borne, and in regard to quantity the same is true. Many of the trees have been so heavily loaded that the branches have broken down. Fig. 7 represents one of these trees. In 1876 Mr. G. M. Bacon moved two trees at Baconton, Georgia. These trees were six years old and well branched. How long their tap-roots were, would be hard to say. Wishing to move the trees, and thinking they would be useless if their tap-roots were injured, he started the men to digging them up. They dug down ten feet, and not coming to the end of the tap-roots, they were cut off at that distance and lifted out. The tap-roots were then cut squarely off, four feet

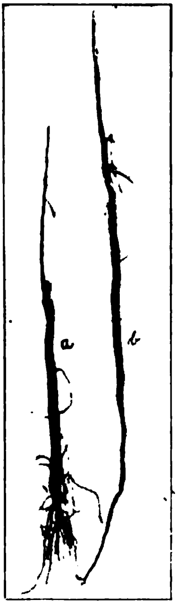

FIG. 6. *a*. Tap-root cut at one year. *b*. Tap-root not cut. (Trees from Mr. Taber. Photo. by the Author.)

from the crown, with a saw, the tops pruned severely, and trees planted out. To-day they are large, well-developed trees (thirty years old) bearing heavy crops of excellent, full-meated nuts.

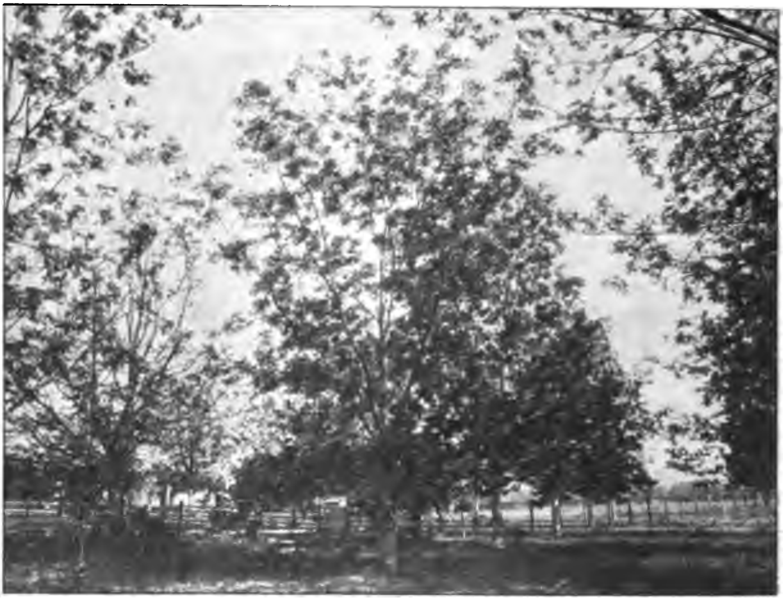

FIG 7. Pecan Tree: tap-root cut at time of planting, showing branches broken by weight of nuts. (Photo. by the Author.)

TOP.

I do not deem it advisable to prune the tops of one and two year old trees at the time of setting out, as there is always a tendency toward the development of several shoots, and it is not essential to the welfare of the tree. If larger trees are transplanted, it will be necessary to cut them back.

Aside from the pruning required for the formation of the head, the top of the pecan requires very little attention in the way of pruning. Usually the top is allowed to take care of itself, but it would be particularly desirable to bring the bearing surface of the tree somewhat closer to the ground. The head may be started at three or four feet from the ground, and as the strong, upright center branches make their growth, they should be cut back, thus inducing growth in the lateral branches and giving the tree a rounded, symmetrical top. Other than this, all the attention the tree will require is the removal of any dead branches which may happen to be found.

BOTANICAL.

The rich alluvial bottoms of the Mississippi and certain of its tributaries is the native home of this tree in the United States. The area as given in "Nut Culture in the United States," * embraces "an obliquely set area, having near its four extremities the cities of Davenport, Iowa, Chattanooga, Tenn., Laredo, Tex., and the region of the headwaters of the Colorado River in Texas." In cultivation, however, it is found far from this region, and has been and is receiving considerable attention in Alabama, Georgia, Florida, and other States not included in its native range.

The pecan belongs to the family *Juglandaceæ* (walnut family), and is known botanically as *Carya olivæformis*, Nutt., and *Hicoria pecan* (Marsh), Britton. It is closely related to the butternut, walnut and the different varieties of hickories.

It is a large, stately tree, 75 to 170 feet in height, with wide, spreading branches and symmetrical top. The bark is rough, broken, and grayish black in color. The bark of the young twigs is quite smooth, and they, during their early life, together with the leaves and flowers of the tree, are covered with a liberal coating of rather rust-colored hairs. The leaves are oval, compound, composed of from seven to fifteen falcate, oblong-lanceolate, sharp-pointed serrate leaflets, green and quite bright above, lighter colored below, and when mature, nearly or quite smooth. The flowers are of two kinds—pistillate and staminate. The former are produced upon the young shoots, while the latter come from buds upon twigs one year old. The staminate catkins are usually produced in two groups of three each, from a single bud. and have very short stalks. The stamens are three to five in number in each flower, and borne beneath a three-parted bract. The pistillate flowers have a four-valved involucre (known in the mature form as the husk). and a two-parted stigma. Fertilization takes place largely through the agency of the wind. The fruit is generally somewhat oblong in form, and varies in weight from about twenty-five nuts to the pound (a cultivated variety, Post's Twentieth Century), to over one hundred. For further descriptions. see under head of varieties.

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* U. S. Dept. Ag., Div. Pomology, 1896.

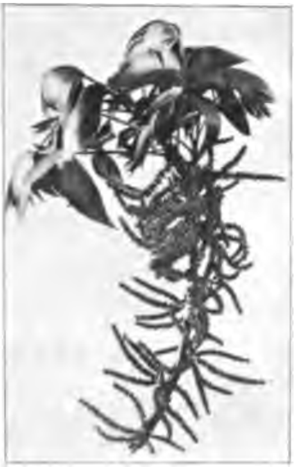

FIG. 8. Staminate Flowers of the Pecan.
(Photo. by the Author.)

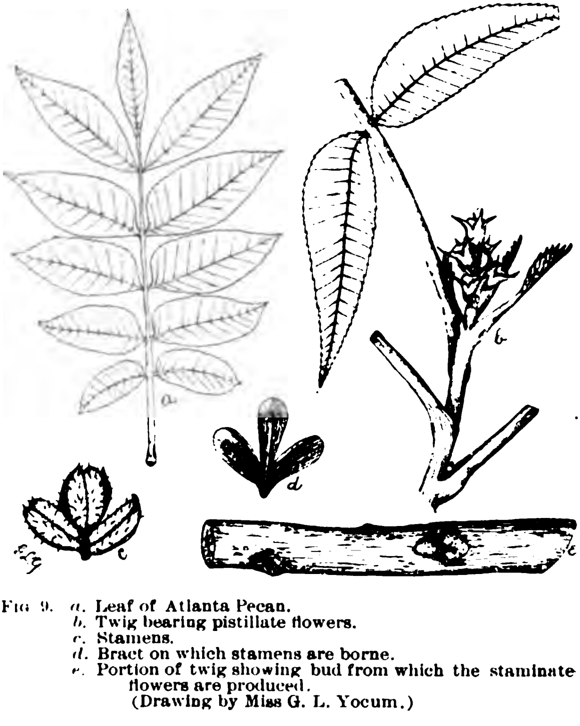

FIG 9. *a*. Leaf of Atlanta Pecan.
b. Twig bearing pistillate flowers.
c. Stamens.
d. Bract on which stamens are borne.
e. Portion of twig showing bud from which the staminate flowers are produced.
(Drawing by Miss G. L. Yocum.)

VARIATIONS IN CULTIVATED VARIETIES.

There are some noteworthy variations in the varieties now under cultivation, but an opportunity has not been afforded for carefully studying these. The heads of some are quite compact, the branches having an upright habit of growth, while the tops of others are open, with the branches spreading and somewhat drooping. The leaves, too, present considerable diversity of form, both in general outline and in the shape of individual leaflets, the foliage of some trees being quite characteristic. The blossoming period varies in a very marked degree, the flowers of some trees opening and the fruit having set before others show any sign of putting forth flowers.

This latter fact should be borne in mind in planting budded varieties, for self-sterility apparently exists in the pecan to a certain degree. To what extent this is true of the cultivated varieties I am not aware, but it is the only plausible explanation of some cases of unfruitfulness, in isolated pecan seedlings, which have come under my observation; hence, to be on the safe side, and in the absence of more certain knowledge, I do not deem it advisable for anyone to plant solid blocks of one variety only. Several should be chosen and planted together in order to guard against the possibility of unfruitfulness due to this cause.

PRODUCTION OF NEW VARIETIES.

The varieties of pecans which are grown at present are almost altogether the offspring of the native trees. The cutivated pecans are generally a great improvement over the wild varieties. The method by which these have been obtained was simply by the planting of nuts from trees which had large or otherwise desirable fruit. So far as I am aware, no attempts have been made at crossing the different varieties with a view to obtaining better nuts. The results to be obtained from such work would doubtless be as desirable as those obtained by breeding other fruits. Considerable time — six to eight years — would necessarily have to pass before the results would be known, as the tree is slow in coming into bearing. The operation of fertilizing the blossoms would be comparatively simple, as the somewhat tedious operation of emasculation would be obviated on account of the fact that the female flowers are produced separate from the male. The production of new varieties by this means opens up a large field for future work.

VARIETIES.

A great deal of stress has been laid upon a thin shell as a mark of virtue in a pecan nut; in fact, this point seems to have often received attention at the expense of other and more important ones. True, a thin shell is to be desired, both because it is more easily cracked and because a greater proportion of meat can be secured from a pound of nuts, but it should not be given undue prominence.

The following are the points which it seems desirable to consider in determining the vulue of a pecan: Quality and flavor, plumpness of kernel, ease with which the kernel separates, size, and the thickness of the shell. The ease of separation depends largely upon the convolutions in the kernel. For market the large and medium sized nuts are perhaps more desirable, while the smaller ones are well adapted for the home table. It should be borne in mind, however, that the medium and small sized nuts are usually somewhat better in quality and finer flavored.

The following varieties are grown either in Florida or Georgia. Some of them, such as Stuart, Van Deman, Centennial and Frotchers are what may be termed standard varieties, while the remainder are for the most part new introductions. Some of these are particularly commendable, and are well worthy of a place among the list of desirable varieties. A few of the varieties have already been described in "The American Fruit Culturist," by Thomas, and in the excellent monograph entitled "Nut Culture in the United States," Division of Pomology, U. S. Department of Agriculture, 1896.

The numbers correspond with those on the plates, and the cross section of each variety is shown to the right of the external view.

1. Egg — Medium; ovate; shell thin; partitions thin; kernel plump; quality good. D. L. Pierson, Monticello, Fla. Grown from seed procured from Louisiana in 1889.
2. Louisiana — Large; oblong; shell thin; partitions thin; full meated; quality very good. D. L. Pierson.
3. Jumbo — Large; ovoid; shell thin; partitions rather thick and corky; quality very good. Specimen from which drawing was made came from D. L. Pierson.
4. Ladyfinger[1] — Small; oblong, pointed; kernel plump, separating easily; sweet; a small nut of excellent quality. D. L. Pierson. Tree growing on Mr. Pierson's place when bought, and now probably twenty-five years old. Fruit ripens in September.
5. Turner — Medium; elliptical oblong; shell thin; partitions slightly corky; kernel plump, sweet; quality excellent. G. L. Taber, Glen St. Mary, Fla.
6. Frotchers — Large; oblong-ovoid; shell quite thin; kernel plump and sweet; quality good. Specimens from which drawings were made were received from Dr. J. B. Curtis, Orange Heights, Fla.
7. Van Deman — Large; oblong; shell thin; partitions rather corky; kernel rather plump; quality good. Specimen from Dr. J. B. Curtis.
8. Stuart — Large; somewhat ovoid; shell thin; partitions somewhat corky; kernel plump; quality very good. Specimens from Dr. J. B. Curtis.
9. Curtis[2] — Medium; oblong conical; shell thin; partitions thin; kernel full and plump; quality excellent. Dr. J. B. Curtis, Orange Heights, Fla. Tree grown from seed obtained from Arthur Brown, Bagdad, Fla., in 1886. First nuts borne in 1893.
10. Randall[2] — Medium; slightly larger than Curtis; ovate; shell slightly thick; kernel plump, separating easily; quality very good. Dr. J. B. Curtis, Orange Heights, Fla. Grown from seed obtained from Arthur Brown, Bagdad, Fla., in 1886.

11. Hume[2] — Medium; oblong; shell and partitions thin; kernel full, plump; quality very good. Dr. J. B. Curtis, Orange Heights, Fla. Grown from seed obtained from Arthur Brown, Bagdad, Fla., in 1886.

12. Centennial — Large; oblong, and usually rather constricted in the middle; shell medium in thickness; partitions rather thick and corky; kernel plump; quality good. Specimens for drawings were received from W. H. Haskell, DeLand, Fla.

13. Georgia Giant — Very large, ovate, or ovate oblong; kernel large; shell thin; a good deal of corky substance in the partitions; quality good. Weight, 32 to 34 to the pound. G. M. Bacon, DeWitt, Ga.

14. Magnum Bonum — Medium; ovate; shell thin; partitions thin; kernel plump, sweet; quality very good. G. M. Bacon, DeWitt, Ga.

15. Bacon — Medium; slightly ovate, flattened, creased toward the apex; shell thin; partitions thin, corky substance absent; kernel plump, separating easily; quality excellent. G. M. Bacon, DeWitt, Ga.

16. Atlanta — Medium; oblong, pointed; shell thin; kernel plump; quality very good. G. M. Bacon, DeWitt, Ga.

17. Senator — Medium; ovate; shell and partition thin; kernel full and plump; quality excellent. G. M. Bacon, DeWitt, Ga.

Number 18 is a very thin-shelled nut, here given as an example of the extreme to which the "thin-shelled" idea may be carried. The thin shell is the only recommendation it has. The kernel soon became rancid.

---

[1] A. S. Fuller, in his book entitled "The Nut Culturist," makes reference to a variety called Ladyfinger, which had been forwarded to him by a correspondent, but as no description is given of it, I have retained the name Ladyfinger for the variety forwarded by Mr. Pierson.

[2] These were known for some time as Curtis Nos. 2, 3 and 5, respectively, and were named as above by Dr. J. B. Curtis.

NURSERYMEN.

The following are a few of the nurserymen in the South from whom pecan trees may be obtained. The list is not complete by any means, as it is simply composed of those who have forwarded catalogues or supplied specimens or information.

Bacon, G. M., DeWitt, Ga.
Bacon, R. J., Baconton, Ga.
Curtis, Dr. J. B., Orange Heights, Fla.
Gillette, M. E., Tampa, Fla.
Girardeau, J. H., Monticello, Fla.
Griffing Brothers Company, Jacksonville, Fla.
Haskell, W. H., DeLand, Fla.
Pierson, D. L., Monticello, Fla.
Post Seed Pecan Company, Fort Worth, Tex.
Stuart Pecan Company, Ocean Springs, Miss.
Taber, G. L., Glen St. Mary, Fla.

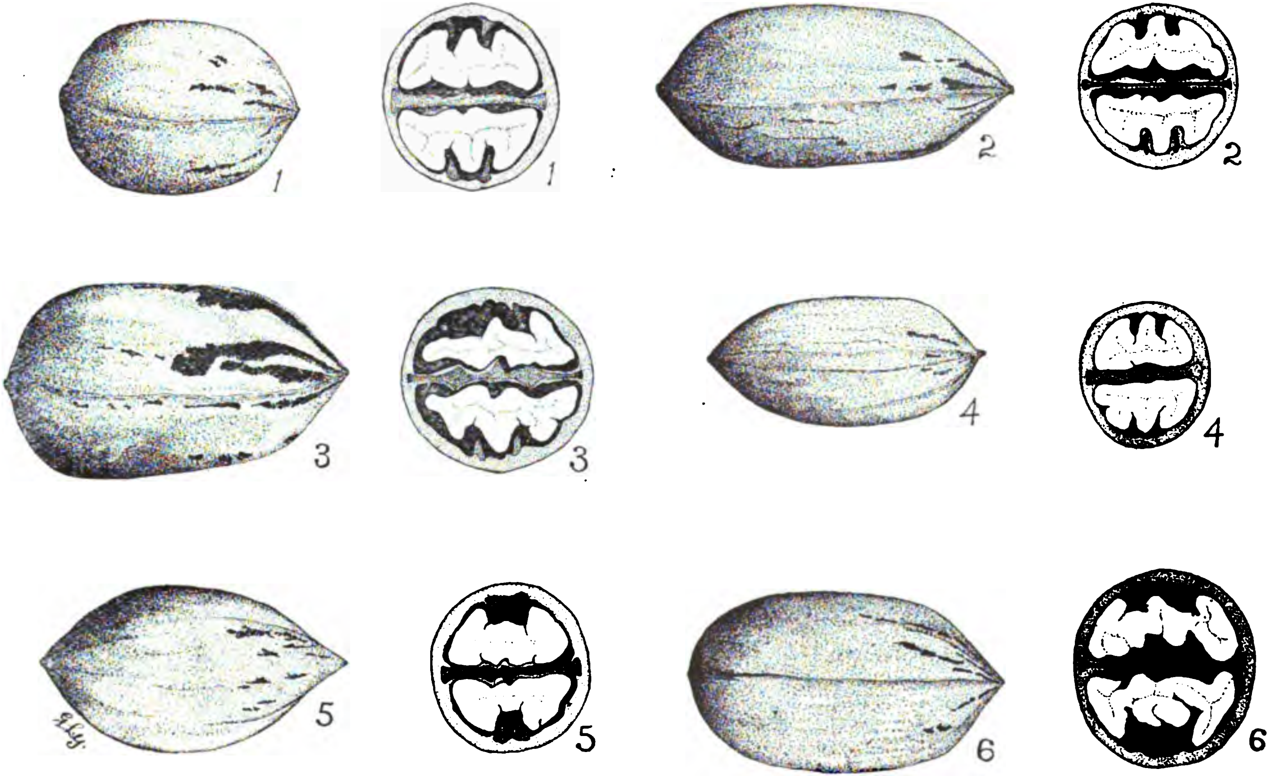

Plate I.—VARIETIES OF PECANS. (Drawing by Miss G. L. Yocum.)

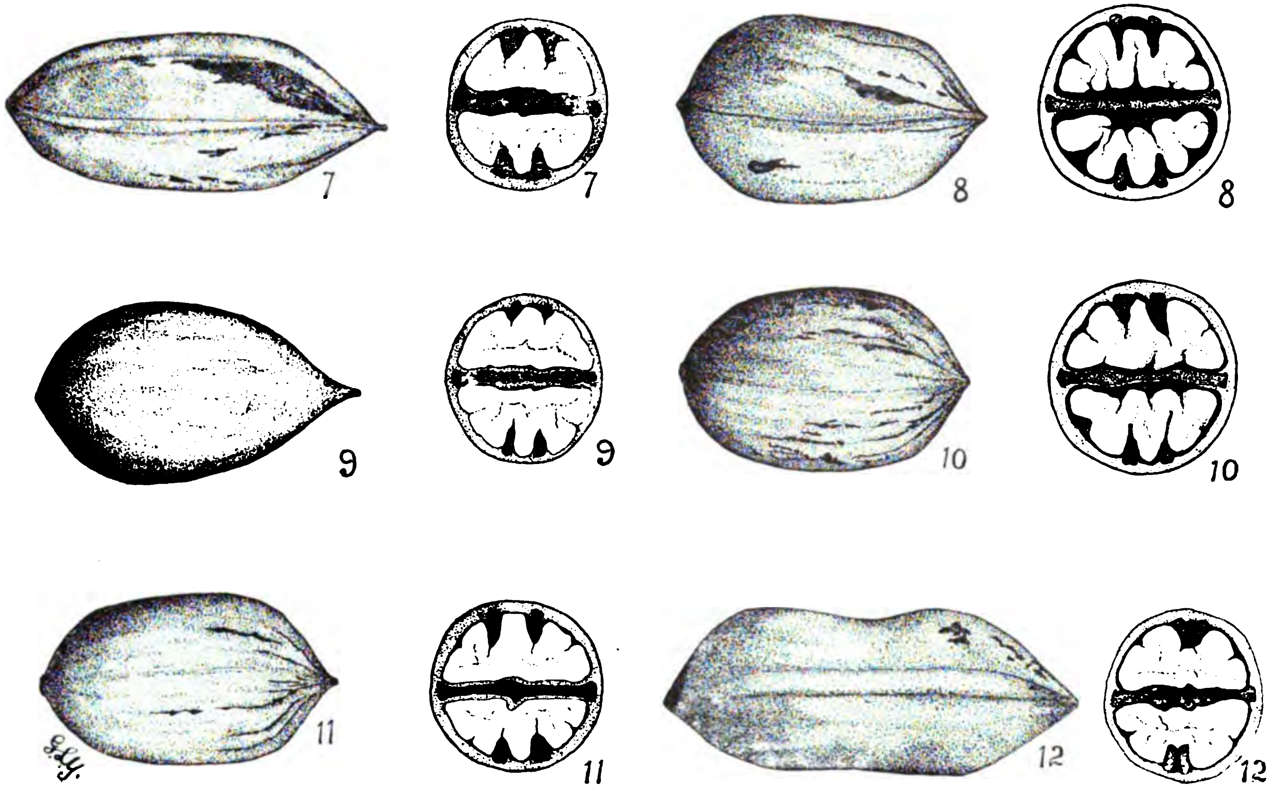

Plate II.—VARIETIES OF PECANS. (Drawing by Miss G. L. Yocum.)

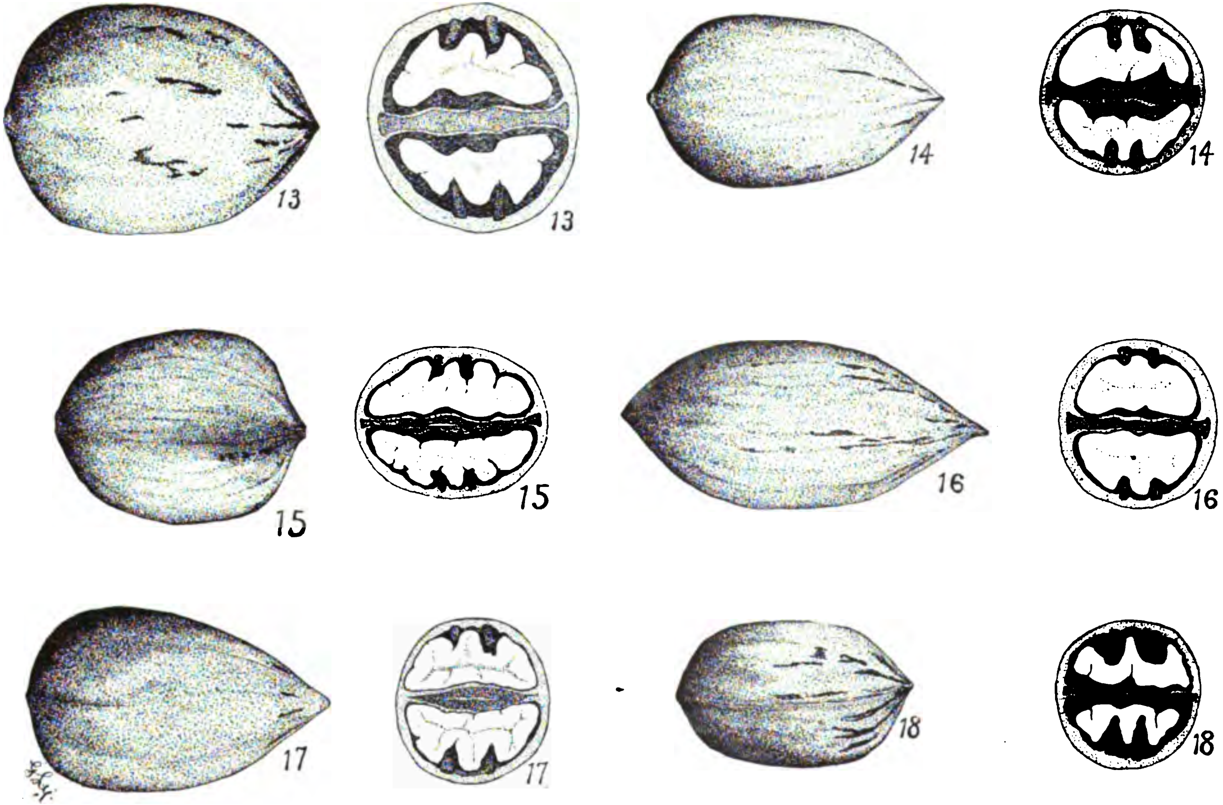

Plate III.—VARIETIES OF PECANS. (Drawing by Miss G. L. Yocum.)

BULLETIN 55. **SEPTEMBER, 1900.**

FLORIDA
AGRICULTURAL EXPERIMENT STATION.

Feeding with Florida Feed Stuffs.

BY H. E. STOCKBRIDGE, PH. D.

VANCE PRINTING CO.
JACKSONVILLE, FLORIDA,
1900.

The Bulletins of this Station will be sent free to any address in the State upon application to the Director, Lake City, Florida.

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INTRODUCTION.

FLORIDA CONDITIONS.—The State of Florida, as a whole, possesses very exceptional natural advantages for most forms of stock husbandry. There are millions of acres of cheap or free range covered with natural grasses and forage plants, furnishing excellent pasturage for all classes of animals, and our climatic conditions are such that this pasturage is available at all seasons of the year. The natural range is mostly timbered sufficiently to furnish protection against storms in winter and against sun in summer. It is watered abundantly with never-failing supplies of the best and purest water either from springs, streams or lakes, and the climate is so mild that shelter, except from rain, even during the severest weather, is superfluous. These conditions have long been recognized by residents, and the stock industry has for many years been one of the leading resources of the State. There are hundreds of thousands of cattle grown and pastured on Florida ranges, and many more could be easily accommodated. The industry as heretofore followed, however, has been confined almost exclusively to the mere ranging of droves of comparatively inferior animals, which have been mostly marketed in the West Indies, or have furnished low-priced raw material for the stock feeders of the corn States. The soils and climate of Florida are perfectly adapted to the successful growth of cultivated grasses and forage crops adapted to the fattening of animals. These facts suggest the economy and advantages of a radical change in the form of stock husbandry followed, namely, the substitution of better animals and more systematic care, and finally the feeding and fattening of the animal when grown, and the supplying of local and outside markets with a finished product instead of the low-priced raw material heretofore produced. These conditions are fully recognized by the more progressive stockmen of the State, particularly as new conditions become more and more prominent, and the day of smaller land holdings and fenced proprietorship approaches. The object of this bulletin is not so much the calling of attention to new conditions and new facts, as it is the furnishing of evidence of the correctness of opinions already entertained; reasons for the faith of many people in the superior advantages possessed by our State for the profitable production of fat beef and pork for the best markets.

It is believed that many of our local conditions are such as to render successful competition from other sections of the country impossible, and it is thought that the experiments, the results of which are here recorded, will lend additional data for the support of such opinions. Economical or rational stock feeding has heretofore been almost unknown in Florida. No systematic experiments along these lines have before been undertaken by this station, and no bulletin upon the subject of the principles involved has been published here. It seems, therefore, that a review of the principles on which the practice of economical meat production rests should precede any detailed account of our own experiments conducted in accordance with such principles.

Principles Involved.—This bulletin is not intended for those who already know all about stock-feeding, but is intended as an actual means of practical assistance to those desiring to follow the business with economy and profit. Such people, it is believed, will appreciate a simple statement of the principles involved.

It is known to all intelligent observers that animal food consists primarily of two different classes of materials performing two distinct offices in the animal organism. These are classified as protein, or flesh-forming substances, and carbonaceous or fat-forming substances. The former supply the material for muscular oxidation and waste, and the latter for maintaining animal heat. Even the most casual observer recognizes the fact that a single food or a single class of foods cannot supply all the demand of any animal, and that the best results from feeding are only possible when both these different forms of material are supplied in certain proportions. In the daily life of human beings this fact is constantly recognized in practice, even though frequently with no actual recognition of the underlying principle or reason. We demand pork with beans, peas with side meat, macaroni with cheese, potatoes with beef, and fish with rice, not simply because custom justifies the practice, but because custom is founded on the natural demands of the animal organism for both flesh-forming and fat-forming food, and the demand or craving is supplied by combining the two different foods in the cases mentioned. If it is true that the best results in animal nutrition are only secured by associating in the food or ration proportions of these two different kinds of material, the conclusion is inevitable that some proportion between the different constituents must be better, more economical, more productive, more successful than others. The combining of proportions to give best results cannot be at random or haphazard, sometimes in one proportion and sometimes in another; for best results a fixed relation must exist between the proportion of each of these ingredients consumed by any given person or animal. This relation has been thoroughly and systematically studied for many years and has been carefully worked out for each class of live-stock under each of the varying conditions of existence, so that today it is known positively what proportions of protein and carbonaceous matters must be combined in the ration of any animal to result in the greatest degree of success under any condition, age or surrounding of the animal in question. The practice of this economical or scientific compounding or proportioning of foods is appropriately called *rational feeding*, and the experiments here recorded were undertaken in the line of such feeding, as applied to native Florida animals and the use of native Florida feed stuffs, in the hope of establishing the conditions under which our animals and feeds could be utilized with the greatest profit to the feeder.

Field of Velvet Beans in Bloom.

I.

RATIONAL FEEDING.

Uses of Food.—The purpose of food is to supply the animal with necessary nutriment. The different constituents of the food supplying essential ingredients to the animal organism are, therefore, called nutrients. Their office is, briefly speaking, to sustain the animal body and enable it to transform food into other valuable products, such as flesh, wool, milk, and energy or work. The general purpose of nutriment is to furnish the animal organism with the material of which it is made, that is, to form muscle, blood, bones, fat and tissue. A very considerable portion of the food, however, is utilized to supply the wastes of animal existence, provide muscular oxidation, and to maintain animal heat by keeping up the high temperature of the body.

Classification of Foods.—Food is classified according to composition, or really according to the function it performs in the animal organism. The simplest classification is that which separates nutritive substances into carbonaceous, or fat and heat-forming materials, and protein, or muscle-forming materials. In addition to these, however, all foods contain water, which is also a large constituent of animal bodies, and ash, or mineral matter, which enters not only into the composition of all animal tissues, but is the chief constituent of the bones. The carbonaceous foods are subdivided into carbo-hydrates, of which starch, sugar, and fiber are illustrations, and fats, which are simply oils stored up in the animal tissues. Protein foods include several different classes of chemical compounds, the important characteristic of which is the presence of nitrogen in one or another of its combined forms. This is, therefore, the predominating constituent of muscle, of blood, of eggs, and of the casein of milk.

Composition of Foods.—From what has already been stated, it is readily seen that the food must furnish to the animal body the material of which it is formed, and that, therefore, the foods consist of the elementary constituents of which the body is composed.

Food is divided into	Dry Matter and Water,
Dry Matter into	Organic Matter and Inorganic Matter,
Organic Matter into	Protein Fats and Carbo-hydrates.

Few foods contain these different constituents in the proportions required by different animals, so that the compounding of rations from materials of different compositions is essential if the greatest degree of economy is to be secured. Knowledge of the function performed in the animal organism by the different nutrients is essential to economy in ration-making. Protein is the basis of blood, muscle, tendons, ligaments, hide, skin, marrow, horns, and hoofs. It is converted into fat and is a source of heat and energy. Fats are animal fuel for the maintenance of heat and energy. They are also stored in the tissues of the body. Carbo-hydrates and fiber are converted into fats and are sources of heat and energy. Mineral matter is the chief constituent of bones and enters into the composition of all parts of the animal organism. Carbo-hydrates are the most abundant and the cheapest of nutrients, while the proteins are the most expensive. It, therefore, follows that, although protein may be converted into heat and energy, carbo-hydrates are a more economical source and should be utilized as far as possible for this purpose. It must, therefore, appear that the economical use of feedstuffs and their effect upon the animal system depend chiefly upon the composition of the materials to be used.

Digestibility of Foods.—Not all of any food is actually assimilated by the animal or is really nutriment; only a portion of the contents of any article of diet is actually digestible, and, therefore, performs any vital function in animal sustenance. The remainder, which is not digestible and not used by the system, is excreted. The amount or proportion of digestible matter in every food has been carefully investigated and determined for all classes of animals under all the various conditions to which they are subjected. The digestible portion of any food expressed in the form of percentage is known as the *digestion coefficient of that food.* In the compounding of rations and the use of tables of food constituents only the digestible portion of the food should be considered. For the sake of convenience the digestion coefficient of foods is eliminated from further consideration here, and in the following table of the composition of feedstuffs only the actual constituents of the food are considered, though for comparison both the entire composition and the actual amount of digestible material are given.

Nutritive Ratio.—As the digestible portion of most foods contains both carbonaceous and protein constituents, and as the effect of the food and its feeding value depend chiefly upon the proportion existing between these two classes of nutrients, a knowledge of which is essential to the intelligent and economical use of foods in compounding balanced rations, this relation is expressed in the form of a simple ratio, known as the "nutritive ratio", of the food in question. Tables of feedstuffs and feeding standards usually include this item, and the term nutritive ratio simply means the relation, proportion, or ratio between the protein and carbonaceous constituents of the food; for instance, the nutritive ratio of corn fodder is expressed as 1:12. This expression means that in the digestible portions of corn fodder there are twelve parts of carbonaceous food to one part of protein. In other words, that there is twelve times as much fat-forming as of flesh-forming nutriment present. So also the nutritive ratio of the food required by any given animal under different circumstances is known; for instance, for feeding steers the ratio should be 1:6.5. By this term is meant simply that in the ration for fattening steers the best results are secured when the proportion between its protein and carbonaceous parts is as 1:6.5. The nutritive ratio is found by dividing the total amount of digestible protein found by analysis to be present in the food by the amount of digestible carbo-hydrates. To the carbo-hydrates, however, must be added the fat that is present in the food. Experiment has shown that fat is 2.25 times as effective as is the same quantity of other carbonaceous matter in the food. Therefore, the amount of fat stated in the analysis is given 2¼ times as much value as is given to the same quantity of carbo-hydrates. In determining the nutritive ratio of the food the quantity of digestible fat is first multiplied by 2.25; the product is then added to the amount of carbo-hydrates present, and the total digestible protein is then divided by this product. The ratio is called "narrow" or "wide", as the proportion of protein is large or small. 1:3 is a narrow ration, while 1:10 is wide.

FEEDING STANDARDS.—The composition of the different foods available for feeding all classes of live stock being at hand, the question next presenting itself to the feeder is the quantity or proportion of the different ingredients which should be brought together in any ratio to most economically supply the requirements of the animal to be fed. The quantities or proportions adapted to the requirements of the different classes of farm animals have been carefully worked out by different investigators and are known as feeding standards. The standards thus universally adopted are of German origin; the one first largely adopted, and which has until recently been the nearly universal standard, was that proposed by Prof. Wolff of the Hohenheim Experiment Station, in Wurttemberg. This original table has been recently considerably modified by both German and American investigators, and, as now adopted, is properly called the Wolff-Lehmann Standard, Prof. Lehmann, of Berlin, having suggested the chief modifications in the former table. As now arranged and adopted, it includes, for each class of animals under the various conditions to which it is subjected, a statement of the total dry substance, digestible protein, carbo-hydrates, fat, and total nutritive matter required to meet the conditions of each animal to be fed. The amount of food to be consumed by any animal being dependent upon the size or live weight of that animal, the figures comprising the table are made to apply to a definite weight rather than to a mere individual, the weight adopted, unless otherwise specified, being one thousand pounds of each kind of animal. It should be added that these feeding standards are not absolutely definite, inasmuch as they necessarily fail to take into consideration individual idiosyncrasies, characteristics, or temperament. However, they meet the average requirements of normal animals and give by far the nearest approach yet attained to definite and positive control of the assimilation and utilization of animal food.

(*See Tables I and II, pp. 229 to 237, inclusive.*)

USING FEEDING TABLES.—Tables I and II, with the explanations before made, furnish all the data necessary for the compounding of rations to meet the requirements of any individual animal. Their actual use, however, is best illustrated by the working out of a sample ration. Let us suppose, therefore, that it is desired to fatten steers. Reference to Table II shows that the total quantity of the nutrients forming the standard for the first period for fattening steers, for each one thousand pounds of live weight is as follows :

Dry matter	30. lbs.
Protein	2.5 "
Carbo-hydrates	15. "
Fat	0.5 "
Nutritive ratio	1:6.5

The materials on hand for compounding the ration to be fed are as follows: hay, cotton-seed hulls, bran, and corn meal. Reference to the percentage composition of each of these foods, as given in Table I, gives the number of pounds of each of the nutrients in one hundred pounds of the foods mentioned. One pound, therefore, contains one hundredth as much as the quantity stated in the table. Let us, therefore, mix a trial ration consisting of—

Hay	12 lbs.
Cotton-seed hulls	9 "
Wheat bran	8 "
Corn meal	7 "

By multiplying the amount of each nutrient ascertained to exist in one pound of these foods we have the following composition of the ration :

	Pounds.	Dry Matter. Pounds.	Protein. Pounds.	Carbo-hydrates. Pounds.	Fat. Pounds.
Hay	12	5.842	.921	4.749	.154
Hulls	9	3.272	.219	2.908	.208
Bran	8	4.152	.956	2.946	.224
Meal	7	4.996	.372	4.141	.252
Total	36	18.262		14.744	.838
				1.887	× 2.25
			2.468	÷16.631	= 1.887

Ratio, 1: 6.7.

By dividing the sum of the carbo-hydrates and fats shown to be present by the total protein we obtain a quotient

TABLE I.

AVERAGE COMPOSITION OF AMERICAN FEEDING STUFFS.

FEEDING STUFFS.	Percentage Composition.							Per Cent. Digestible Matter.		
	Water.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen—free Extr't.	Ether Extract (Fat).	Organic Matter.	Crude Protein.	Carbo-hydrates.	Ether Extract (Fat).
Green Fodders and Silage.										
Alfalfa (lucern)	71.8	2.7	4.8	7.4	12.3	1.0	25.5	3.6	11.4	.4
Alsike clover, in bloom	74.8	2.0	3.9	7.4	11.0	.9	23.2	2.7	13.1	.6
Blue-grass	65.1	2.8	4.1	9.1	17.6	1.3	32.1	2.9	19.2	.8
Clover silage	72.0	2.6	4.2	8.4	11.6	1.2	25.4	2.0	13.5	1.0
Clover	70.8	2.1	4.4	8.1	13.5	1.1	27.1	2.9	14.1	.7
Corn silage	79.1	1.4	1.7	6.0	11.1	.8	19.5	.8	11.6	.7
Corn, green fodder	79.3	1.2	1.8	5.0	12.2	.5	19.5	1.3	11.8	.4
Oat fodder	62.2	2.5	3.4	11.2	19.3	1.4	35.3	2.7	22.7	1.0
Prickly comfrey	88.4	2.2	2.4	1.6	5.1	.3	9.4	1.4	4.6	.2
Red top, in bloom	64.8	2.3	3.3	9.4	19.1	1.2	32.9	2.3	20.5	.7
Rye fodder	76.6	1.8	2.6	11.6	6.8	.6	21.6	2.1	14.1	.4
Soja bean ensilage			3.06						8.9	1.5
Sorghum fodder	79.4	1.1	1.3	6.1	11.6	.5	19.5	.8	12.7	.4
Sorghum silage	76.1	1.1	.8	6.4	15.3	.3	22.8	.6	14.9	.2

TABLE I.—*Continued.*

AVERAGE COMPOSITION OF AMERICAN FEEDING STUFFS.

FEEDING STUFFS.	Percentage Composition.							Per Cent. Digestible Matter.		
	Water.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen—free Extr't.	Ether Extract (Fat).	Organic Matter.	Crude Protein.	Carbo-hydrates.	Ether Extract (Fat).
Green Fodders and Silage—Cont'd.										
Timothy	61.6	2.1	3.1	11.8	20.2	1.2	36.3	2.2	23.0	.7
Velvet-bean vines										
Wire-grass			3.28						53.19	1.72
Hay and Dry Coarse Fodders.										
Alfalfa (lucern)	8.4	7.4	14.3	25.0	42.7	2.2	84.2	10.3	41.4	1.1
Alsike clover	9.7	8.3	12.8	25.6	40.7	2.9	82.0	6.8	36.8	1.4
Barley straw	14.2	5.7	3.5	36.0	39.0	1.5	80.1	.9	41.3	.6
Beggar-weed			11.85					11.85	42.06	2.92
Buckwheat straw	9.9	5.5	5.2	43.0	35.1	1.3	84.6	2.3	37.7	.6
Corn fodder (pulled leaves)			6.63						39.41	2.08
Corn tops			6.30						45.77	1.89
Corn stalks (stover), field cured	40.1	8.4	3.8	19.7	31.9	1.1	56.5	2.0	33.4	.6
Cow pea-vine hay			9.30						38.88	1.24
Crab-grass hay	10.3	7.3	6.9	32.9	41.0	1.6	82.4	2.2	42.8	.6

Fodder corn (maize), field cured	42.2	2.7	4.5	14.3	34.7	1.6	55.1	2.6	33.3	1.1
Hungarian grass	7.7	6.0	7.5	27.7	49.0	2.1	86.3	4.5	46.4	1.0
Mixed meadow grass	16.0	4.6	6.4	29.9	41.0	2.1	79.4	3.6	42.7	1.0
Red clover	15.3	6.2	12.3	24.8	38.1	8.3	78.5	6.5	34.9	1.0
Marsh hay	7.9	5.2	7.8	30.1	46.3	2.7	86.9	3.5	44.7	1.7
Oat hay	8.9	6.2	7.6	29.3	45.1	2.9	84.9	4.3	46.4	1.5
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3	85.7	1.6	41.4	.7
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2	89.7	.8	42.7	.4
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3	86.2	.8	37.9	.5
Velvet-bean hay *	10.0	5.9	14.0	37.7	30.6	1.8	...	...	...	...
Roots and Tubers.										
Artichoke	79.5	1.0	2.6	0.8	15.9	.2	19.5	2.0	16.8	.2
Carrots	88.6	1.0	1.1	1.3	7.6	.4	10.4	1.0	7.1	.3
Cassava	66.6	0.7	.8	1.6	29.8	0.2	...	0.2	17.0	.1
Mangel-wurzels	90.9	1.1	1.4	.9	5.5	.2	8.0	1.1	4.8	.2
Potatoes (Irish	78.9	1.0	2.1	.6	17.3	.1	20.1	1.4	16.1	.1
Potatoes (sweet)	71.1	1.0	1.5	1.3	24.7	.4	27.9	.9	22.2	.3
Rutabagas	88.6	1.2	1.2	1.3	7.5	.2	10.2	.9	7.1	.2
Sugar beets	86.5	.9	1.8	.9	9.8	.1	12.6	1.1	9.3	.1
Turnips	90.5	.8	1.1	1.2	6.2	.2	8.7	.6	5.5	.2
Grains and Mill Products.										
Barley	10.9	2.4	12.4	2.7	69.8	1.8	86.7	9.5	66.1	1.2
Barley screenings	12.2	3.6	12.3	7.3	61.8	2.8	84.2	9.3	57.3	1.8
Broom-corn seed	...	...	7.61	...	...	...	...	...	60.8	3.0
Buckwheat	12.6	2.0	10.0	8.7	64.5	2.2	85.4	7.7	49.2	1.8
Buckwheat bran	10.5	3.0	12.4	31.9	38.8	3.3	86.5	7.4	30.4	1.9
Buckwheat shorts	11.1	5.1	27.1	8.3	40.8	7.6	83.8	21.1	33.5	5.5
Buckwheat middlings	12.7	5.1	28.2	4.2	42.3	7.5	82.2	22.0	33.4	5.4
Corn (maize)	10.9	1.5	10.5	2.1	69.6	5.4	87.6	6.3	64.8	5.0
Corn and cob meal	15.1	1.5	8.5	6.6	64.8	3.5	83.4	6.5	56.3	2.9
Corn cob	10.7	1.4	2.4	30.1	54.9	.5	87.9	1.6	43.9	.3

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* Average of analyses of samples taken at four periods of growth, beginning when the fruit was set and ending when the beans were mature.

TABLE I.—*Continued.*

AVERAGE COMPOSITION OF AMERICAN FEEDING STUFFS.

FEEDING STUFFS.	Percentage Composition.							Per Cent. Digestible Matter.		
	Water.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Ether Extract.	Organic Matter.	Crude Protein.	Carbo-hydrates.	Ether Extract.
Grains and Mill Products—Cont'd.										
Corn bran (hulls)	9.1	1.3	9.0	12.7	62.2	5.8	89.6	7.4	59.8	4.6
Cow pea	14.8	3.2	20.8	4.1	55.7	1.4	82.0	18.3	54.2	1.1
Oats	11.0	3.0	11.8	9.5	59.7	5.0	86.0	9.1	44.7	4.1
Oat shorts	10.0	5.2	16.2	7.5	54.5	6.6	84.8	12.6	45.7	5.4
Oat feed	7.7	3.7	16.0	6.1	59.4	7.1	88.6	12.5	46.9	2.8
Oat hulls	7.3	6.7	3.3	29.7	52.1	1.0	86.0	1.3	40.1	.6
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2	86.9	18.0	56.0	.9
Rice	12.4	.4	7.4	.2	79.2	.4	87.2	4.8	72.2	.3
Rice bran	9.7	10.0	12.1	9.5	49.9	8.8	80.3	5.3	45.1	7.3
Rice hulls	8.2	13.2	3.6	35.7	38.6	.7	78.6	1.6	44.5	.6
Rice polish	10.0	6.7	11.7	6.3	58.0	7.3	83.3	9.0	56.4	6.5
Rye	11.6	1.9	10.6	1.7	72.5	1.7	86.5	8.3	65.5	1.2
Rye bran	11.6	3.6	14.7	3.5	63.8	2.8	84.8	9.7	48.0	1.6
Rye shorts	9.3	5.9	18.0	5.1	59.9	2.8	85.8	11.9	45.1	1.6
Soja beans	10.8	4.7	34.0	4.8	28.8	16.9	84.5	29.6	17.9	15.9

Sorghum seed	12.8	2.1	9.1	2.6	69.8	3.6	85.1	7.0	52.1	3.1
Velvet beans	....	....	17.9	....	....	....	....	....	53.50	6.3
Wheat	10.5	1.8	11.9	1.8	71.9	2.1	87.7	9.2	64.9	1.4
Wheat bran—roller process	12.0	5.6	16.1	8.4	53.7	4.2	82.4	12.6	44.1	2.9
Wheat shorts	11.8	4.6	14.9	7.4	56.8	4.5	83.6	11.6	45.4	3.2
Wheat middlings	12.1	3.4	15.7	4.7	60.2	4.0	84.5	12.2	47.2	2.9
Wheat screenings	11.6	2.9	12.5	4.9	65.1	3.0	85.5	9.8	51.0	2.2
Miscellaneous Feeds.										
Apples	84.8	.5	.4	1.5	12.5	.3	14.7	.3	12.8	.2
Apple pomace	76.7	.5	1.4	3.9	16.2	1.3	22.8	1.0	11.9	1.1
Beet molasses	20.8	10.6	9.1	....	59.5	....	68.6	9.1	59.5	....
Beet pulp	89.8	.6	.9	2.4	6.3	....	9.6	.6	7.3	....
Brewers' grains, wet	75.7	1.0	5.4	3.8	12.5	1.6	23.3	3.9	9.5	1.3
Brewers' grains, dried	7.7	3.6	22.2	12.3	47.9	6.3	88.7	16.2	35.5	5.3
Buttermilk	90.1	.7	4.0	....	4.0	1.1	9.2	3.9	4.0	1.1
Chicago gluten meal	9.5	.9	35.8	1.5	46.8	5.6	89.6	32.2	44.1	5.1
Corn oil-cake	9.0	2.4	24.8	6.7	43.6	13.5	88.6	22.3	42.6	12.3
Cotton-seed meal	8.2	7.2	42.4	5.6	23.8	12.9	84.6	36.9	18.1	12.3
Cotton-seed hulls	9.9	2.9	4.2	47.4	33.2	2.2	87.2	1.0	26.2	1.8
Dried blood	8.5	4.7	84.4	....	....	2.5	86.8	58.1	....	2.3
Germ meal (corn germ)	10.4	3.6	10.0	5.0	64.2	6.8	86.0	9.0	61.2	6.2
Gluten feed	8.3	.9	21.6	6.8	49.6	12.7	90.8	18.6	48.3	11.1
Grano-gluten	5.7	2.7	31.0	11.4	34.8	14.2	91.6	26.7	38.8	12.4
Hominy chops (meal)	10.9	2.5	9.9	3.7	64.4	8.5	86.6	8.9	61.0	7.8
Linseed meal, new process	10.1	5.8	33.2	9.5	38.5	3.0	84.1	27.2	32.9	2.7
Linseed meal, old process	9.2	5.7	32.9	8.9	35.4	7.9	85.1	28.3	32.8	7.1
Malt sprouts	9.6	5.9	24.8	11.0	47.0	1.7	84.5	19.8	36.2	1.7
Meat scraps	10.7	4.1	71.2	....	.3	13.7	85.2	68.4	.3	13.5
Palm-nut meal	10.4	4.3	16.8	24.0	35.0	9.5	85.3	16.0	52.6	9.0

TABLE I.—*Continued.*

AVERAGE COMPOSITION OF AMERICAN FEEDING STUFFS.

FEEDING STUFFS.	Percentage Composition.							Per Cent. Digestible Matter.		
	Water.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Ether Extract.	Organic Matter.	Crude Protein.	Carbohydrates.	Ether Extract.
Miscellaneous Feeds—Continued.										
Pumpkins	90.9	.5	1.3	1.7	5.2	.4	8.6	1.0	5.8	.3
Rape	84.5	2.0	2.3	2.6	8.4	.5	13.5	1.5	8.1	.2
Skimmed milk	90.4	.7	3.3	....	4.7	.8	8.9	3.1	4.7	.8
Sugar-beet leaves	88.0	2.4	2.6	2.2	4.4	.4	9.6	1.7	4.6	.2
Whey	93.4	.7	.9	....	4.8	.3	5.9	.8	4.7	.3

TABLE II.

FEEDING STANDARDS FOR FARM ANIMALS.

(Per day and per 1000 lbs. live weight.)

	Total Dry Substance.	Nutritive (Digestible) Substances.			Total Nutritive Substances.	Nutritive Ratio.
		Crude Protein.	Carbo-hydrates.	Fat (Ether Extract).		
	lbs.	lbs.	lbs.	lbs.	lbs.	
1. Oxen at rest in stall	18	0.7	8.0	0.1	8.9	1:11.8
Oxen slightly worked	22	1.4	10.0	0.3	12 1	1: 7.7
Oxen moderately worked	25	2.0	11.5	0.5	14.7	1: 6.5
Oxen heavily worked	28	2.8	13.0	0.8	17.7	1: 5.3
2. Fattening steers, 1st period	30	2.5	15.0	0.5	18.7	1: 6.5
" " 2d "	30	3.0	14.5	0.7	19.2	1: 5.4
" " 3d "	26	2.7	15.0	0.7	19.4	1: 6.2
3. Milch cows, daily milk yield 11 lbs	25	1.6	10.0	0.3	12.3	1: 6.7
" " " 16.5 lbs	27	2.0	11.0	0.4	14.0	1: 6.0
" " " 22 lbs	29	2.5	13.0	0.5	16.7	1: 5.7
" " " 27.6 lbs.	32	3.3	13.0	0.8	18.2	1: 4.5
4. Wool sheep, coarser breeds	20	1.2	10.5	0.2	12.2	1: 9.1
" " finer breeds	23	1 5	12.0	0.3	14.2	1: 8 5
5. Breeding ewes, with lambs	25	2.9	15.0	0.5	19.1	1: 5.6
6. Fattening sheep, 1st period	30	3.0	15 0	0.5	19.2	1: 5.4
" " 2d "	28	3.5	14.5	0.6	19.4	1: 4.5

TABLE II.—*Continued.*

FEEDING STANDARDS FOR FARM ANIMALS.

(*Per day and per 1000 lbs. live weight.*)

	Total Dry Substance.	Nutritive (Digestible) Substances.			Total Nutritive Substances.	Nutritive Ratio.
		Crude Protein.	Carbo-hydrates.	Fat (Ether Extract).		
	lbs.	lbs.	lbs.	lbs.	lbs.	
7. Horses lightly worked	20	1.5	9.5	0.4	12.0	1:7.0
Horses moderately worked	24	2.0	11.0	0.6	14.5	1:6.2
Horses heavily worked	26	2.5	13.3	0.8	17.7	1:6.0
8. Brood sows, with pigs	22	2.5	15.5	0.4	19.0	1:6.6
9. Fattening swine, 1st period	36	4.5	25.0	0.7	31.2	1:5.9
" " 2d "	32	4.0	24.0	0.5	29.2	1:6.3
" " 3d "	25	2.7	18.0	0.4	22.0	1:7.0
10. Growing cattle—Dairy breeds:						
Age, Months. Aver. Live Weight per Head.						
2-3 154 lbs.	23	4.0	13.0	2.0	21.8	1:4.5
3-6 309 "	24	3.0	12.8	1.0	18.2	1:5.1
6-12 507 "	27	2.0	12.5	0.5	15.7	1:6.8
12-18 705 "	26	1.8	12.5	0.4	15.3	1:7.5
18-24 882 "	26	1.5	12.0	0.3	14.2	1:8.5

11. Growing cattle—Beef breeds:							
2-3	165 lbs	23	4.2	13.0	2.0	20.0	1:4.2
3-6	331 "	24	3.5	12.8	1.5	19.9	1:4.7
6-12	551 "	25	2.5	13.2	0.7	17.4	1:6.0
12-18	750 "	24	2 0	12.5	0.5	15.7	1:6.8
18-24	937 "	24	1.8	12.0	0.4	14.8	1:7.2
12. Growing sheep—Wool breeds:							
4-6	62 lbs	25	3.4	15.4	0.7	20.5	1:5.0
6-8	75 "	25	2.8	13.8	0.6	18.0	1:5.4
8-11	84 "	23	2.1	11.5	0.5	14.8	1:6.0
11-15	90 "	22	1.8	11.2	0.4	14.0	1:7.0
15-20	99 "	22	1.5	10.8	0.3	13.0	1:7.7
13. Growing sheep—Mutton breeds:							
4-6	66 lbs	26	4.4	15.5	0.9	22.1	1:4.0
6-8	84 "	26	3.5	15.0	0.7	20.2	1:4.8
8-11	101 "	24	3.0	14.3	0.5	18.5	1:5.2
11-15	121 "	23	2.2	12.6	0.5	16.0	1:6.3
15-20	154 "	22	2.0	12.0	0.4	15.0	1:6.5
14. Growing swine—Breeding animals:							
2-3	44 lbs	44	7.6	28 0	1.0	38.0	1:4.0
3-5	99 "	35	5.0	23.1	0.8	30.0	1:5.0
5-6	121 "	32	3.7	21.3	0.4	26.0	1:6.0
6-8	176 "	28	2.8	18.7	0.3	22.2	1:7.0
8-12	265 "	25	2.1	15.3	0.2	17.9	1:7.5
15. Growing fat pigs:							
2-3	44 lbs	44	7.6	28.0	1.0	38.0	1:4.0
3-5	110 "	35	5.0	23.1	0.8	30.0	1:5.0
5-6	143 "	33	4.3	22.3	0.6	28.0	1:5.5
6-8	198 "	30	3.6	20.5	0.4	25.1	1:6.0
8-12	287 "	26	3.0	18 3	0.3	22.0	1:6.4

of 6.7; in other words, the nutritive ratio of the ration thus made up is 1 : 6.7. We find, therefore, that the ration is slightly "wide", that is, it contains a small excess of carbo-hydrates. Therefore, it must be slightly modified, that the carbo-hydrates may be reduced and the proportion of proteins increased. This is best done by increasing the quantity of hay one pound and diminishing the quantity of cotton-seed hulls two pounds. As the result we have the following ration, the nutritive ratio of which is 1 : 6.5.

	Pounds.	Dry Matter. Pounds.	Protein. Pounds.	Carbo-hydrates. Pounds.	Fat. Pounds.
Hay	13	6.329	.988	5.155	.167
Hulls	7	2.545	.170	2.262	.172
Bran	8	4.152	.956	2.946	.224
Cornmeal	7	4.996	.372	4.141	.252
Total	35	18.022	2.486	14.504	.815

Ratio, 1 : 6.5.

Any and all rational rations are arranged in this same manner and by the same process. It must be remembered, however, that the cost of the ration will determine the advantage or profit from its use, and that therefore the cost of all the constituents in any ration should be determined before the final ration is decided on. The market value, moreover, does not necessarily have any relation whatever to the nutritive value of any food or ration; for instance, the price of wheat bran fluctuates but very little with the rise or fall in the market value of wheat, being dependent entirely upon the supply and demand of bran itself. Therefore, a ration of low cost may easily be fully as valuable for feeding purposes as one of higher cost, and an expensive ration on the other hand may be no more valuable as food than one costing less money, so that the actual market value of the constituents and the actual cost of the total ration must be estimated before its constituent parts are decided on if the greatest degree of economy is to be secured.

SAMPLE RATIONS.*—Although it is believed that the principles here enumerated and the data furnished will enable any feeder of ordinary intelligence to select and arrange economical and satisfactory rations from available foods to meet the requirements of different classes of animals, the element of time involved is frequently important, so that as further assistance and practical aid to stock owners a few sample rations compounded of the different available Florida feedstuffs are here presented to meet the requirements of each different class of farm stock.

RATIONS FOR FATTENING CATTLE, PER 1000 POUNDS LIVE WEIGHT.

1.	Pounds.
Sweet potatoes	25
Corn fodder	10
Cotton-seed meal	5
Corn meal	10
2.	
Corn fodder	20
Corn and cob meal	12
Cow peas (seed)	8
3.	
Cotton-seed hulls	25
Corn meal	8
Cotton-seed meal	5
4.	
Corn-cob meal	15
Cow peas	10
Crab-grass hay	10

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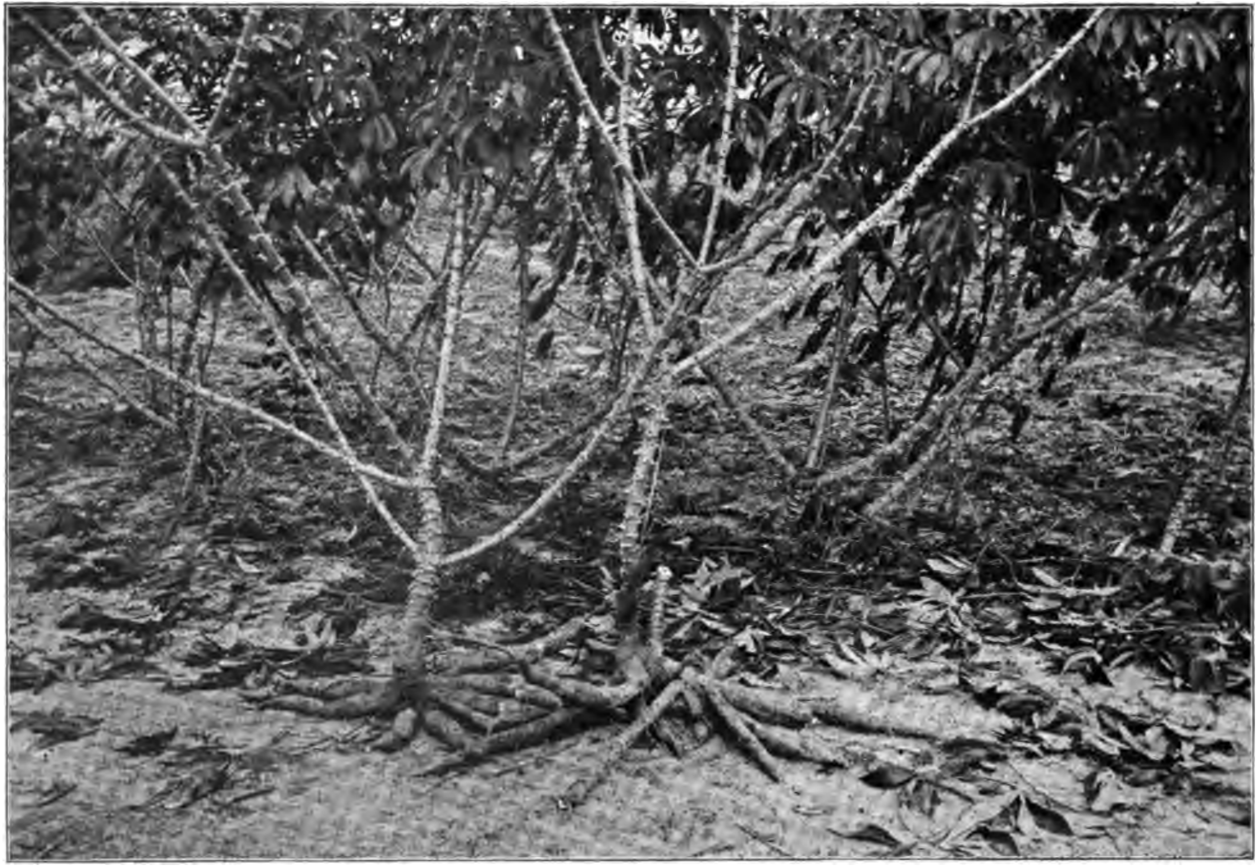
* Most of these rations have actually been in successful use. Several of them were originally suggested by other experiment stations.

RATIONS FOR MILCH COWS, PER 1000 POUNDS LIVE WEIGHT.

1.	Pounds.
Corn meal	4
Wheat bran	4
Cotton-seed meal	4
Pea-vine hay	15
2.	
Rice bran	10
Cotton-seed meal	2
Cassava	12
Crab-grass hay	15
3.	
Cow-pea hay	20
Wheat bran	6
Sweet potatoes	10
4.	
Cow-pea hay	20
Cotton-seed hulls	15
Cotton-seed meal	2
5.	
Crab-grass hay	20
Corn stover	12
Cornmeal	3
Cotton-seed meal	3
6.	
Cow-pea hay	25
Corn meal	4
7.	
Sweet potatoes	25
Corn fodder	10
Cotton-seed meal	4
Corn meal	8
8.	
Corn fodder	18
Wheat bran	4
Cotton-seed meal	4
Corn meal	6
9.	
Rye fodder	30
Wheat bran	6
Cotton-seed meal	2
10.	
Pea-vine hay	12
Cotton-seed meal	2
Wheat bran	4
Cassava	22



Cassava Plants Showing Foliage, Stalks and Roots.

11.	Pounds.
Beggar-weed hay	6
Velvet-bean meal	10
Cassava	30

FOR FATTENING HOGS.

1.	Pounds.
Sweet potatoes	30
Cow peas	9
Corn meal	10
2.	
Cassava	40
Wheat middlings	20
Cow peas	15
3.	
Corn	20
Wheat middlings	40
4.	
Sweet potatoes	30
Cow peas	30

FOR HORSES OR MULES AT HARD WORK, PER 1000 POUNDS LIVE WEIGHT.

1.	Pounds.
Cow-pea hay	15
Oats (grain)	13
2.	
Corn fodder	10
Oats (grain)	15
Cow peas (grain)	4
3.	
Corn fodder	13
Corn meal	11
Cotton-seed meal	3
4.	
Pea-vine hay	16
Cotton-seed meal	3
Corn	2
Cassava	22

In using these rations it must be remembered that the quantity of each article mentioned and the total ration in each case is sufficient to furnish a balanced ration with the suitable quantity and proportion of nutriment to meet the requirements of animals of one thousand pounds live weight. For animals weighing either more or less than this the quantity of food fed must be corrected in proportion to the weight of the animals; for instance, if the animal weighs five hundred pounds, the quantity of each article in any ration should be one-half of the amount stated. This correction for any weight of animal is easily made by the use of a simple proportion.

II.

EXPERIMENTS IN FATTENING STEERS.

OBJECTS OF THE EXPERIMENTS.—Four different questions were experimentally investigated in the hope of securing facts which would settle four points of great importance not only to the cattle owners, but to the State of Florida at large. These were:

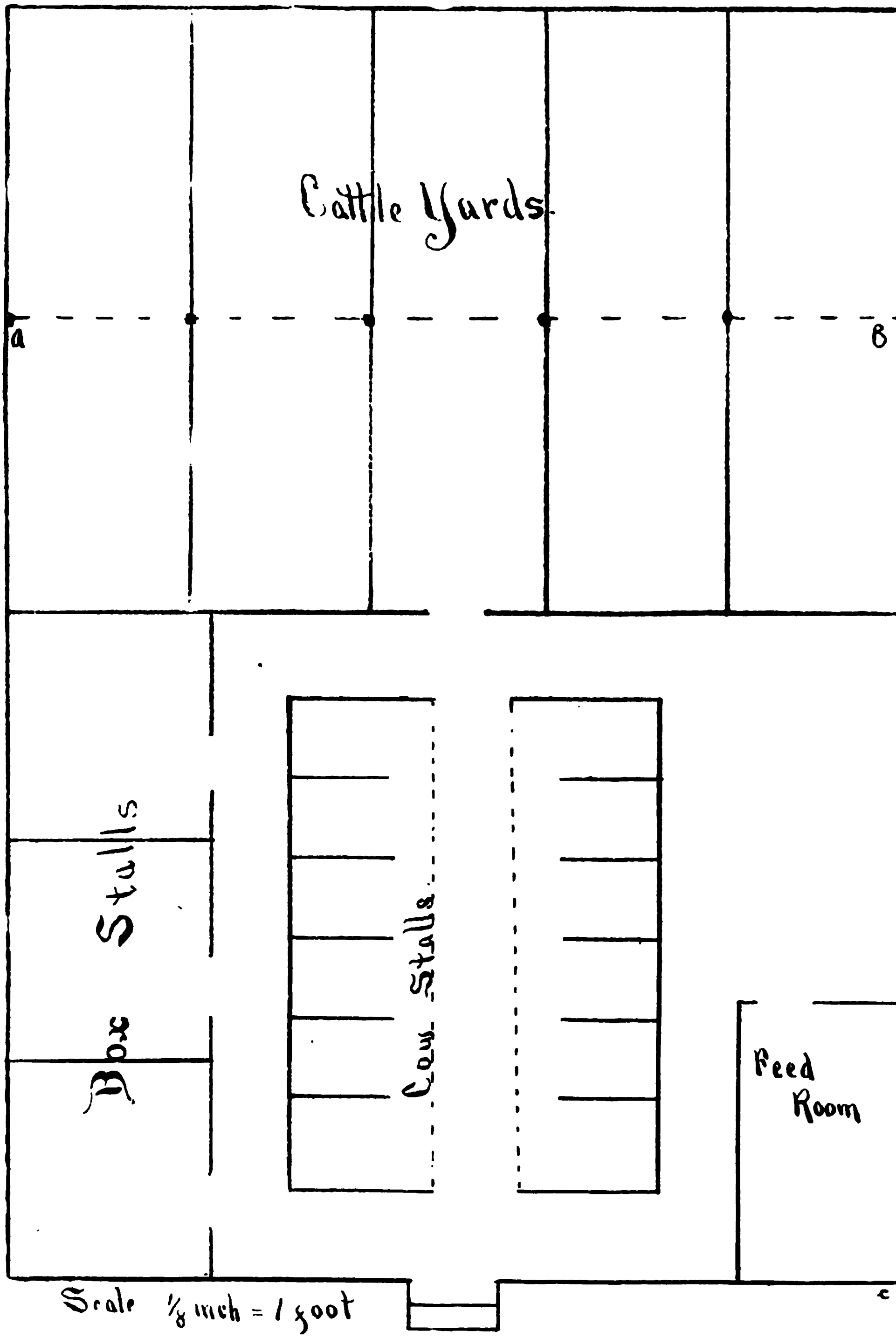
First. Can native Florida range steers be successfully fattened and the product be placed upon the market at a profit?

Second. What ration composed of native Florida feed-stuffs is most profitable?

Third. What length of feeding period would give the most profit, or in other words, how long could the feeding of steers continue under Florida conditions before the cost involved exceeded the value of the product?

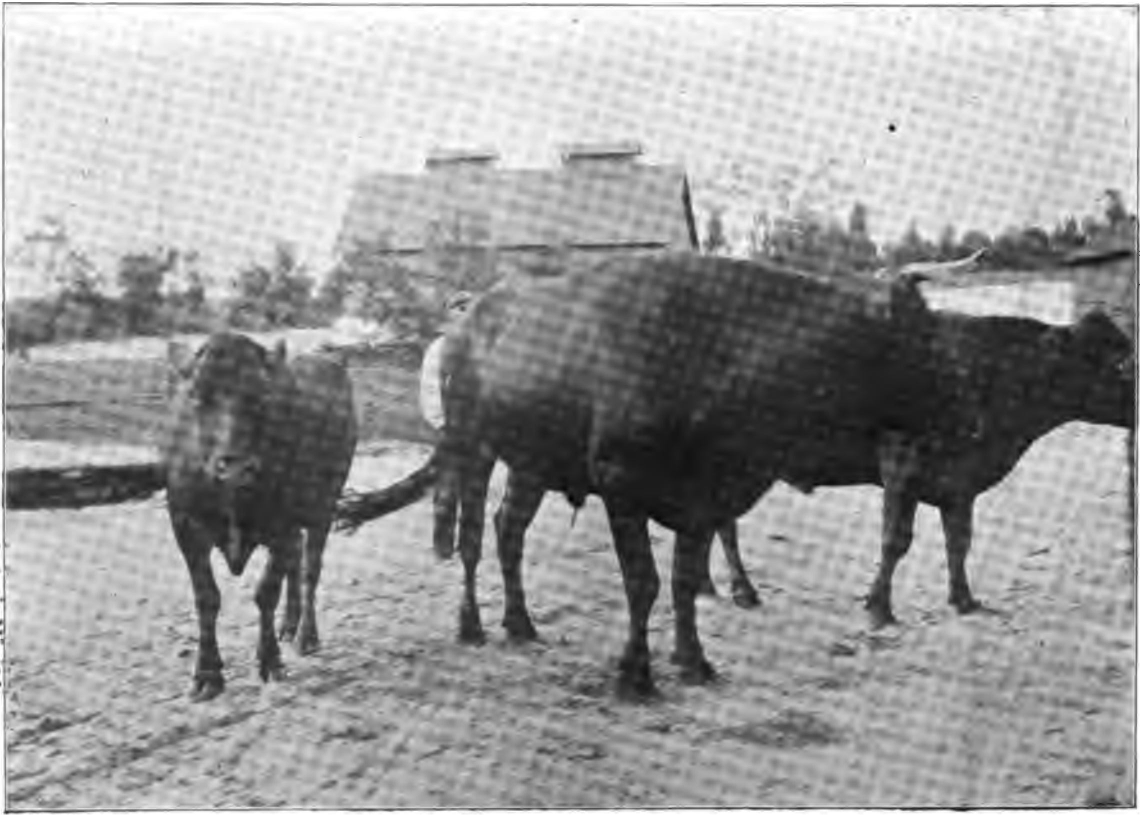
Fourth. Would improved cattle or the introduction of blood from the beef breeds give any advantage over the feeding of native stock?

The three first questions may be answered by one investigation, as a single series of experiments may be made to bear equally upon the three inquries raised. Therefore, two series of tests were sufficient to furnish replies to all four questions, inasmuch as the question of the possibility of feeding and the ration found to be most profitable easily form different divisions of the same inquiry.


Cattle Yards
a
b
Box Stalls
Cow Stalls
Feed Room
c
Scale 1/8 inch = 1 foot

The other point, that is, of the relative success or profit from the feeding of native stock and of improved beef animals, is covered by a parallel test made in connection with the first inquiry.

CHARACTER OF THE ANIMALS USED.—For the purpose of this experiment nine average Florida steers were purchased at the Jacksonville stockyards, having been removed from the range about thirty days previous to coming into our possession. The animals ranged in age from four to seven years and were selected by one of the most experienced stock men in the State as being typical Florida steers, such as exist on the ranges of the State in thousands, and might, therefore, be accepted as fair average representatives of this class of native cattle. They were purchased from the stock yards rather than directly from the range, in order that by selection from a large number an even lot of animals might be secured, and further, that they might already be somewhat used to feeding, so that less time would be lost in getting them accustomed to their rations, and, therefore, on to full feed. On arriving at the Station farm, they were fed together for two weeks, that they might entirely recover from the effects of travel, and that by careful observation any individual peculiarities might be detected which might possibly interfere with the success of the experiment, or a knowledge of which might be useful in dividing the animals into feeding lots. At the end of this preliminary feeding, the nine steers were divided into three lots of three steers each. They were previously weighed, and the division was made as evenly as possible according to weight, age, and temperament, so that in character each lot might be fairly compared with each other lot. The lots were then separated into feeding pens adjoining the barn, each pen being eight feet wide and twenty-four feet long, with a manger and feeding rack at one end of the pen, with an opening into the barn; the feeding end of each pen was under a shed cover. In addition to the three lots thus



Grade Steers (Lot IV).

described, consisting of native Florida steers, three steers were selected expressly for the purpose of making a comparison between the native Florida animal and animals containing improved beef blood, by means of which the relative merits of native and of grade animals might be tested. The three steers selected for this purpose and placed in Lot IV consisted of one grade Short-horn ox, seven years of age, and a pair of grade Red-poled steers, six years old. That these animals possessed very perceptible characteristics of these two beef breeds is demonstrated by the accompanying illustrations taken from photographs. The amount of beef blood possessed by these animals, however, was probably not above one-half and quite probably less. Nothing could be learned of their actual breeding, so that this matter is pure supposition based on the appearance of the animals themselves.

The care and feeding of the different lots were as natural and as applicable to average Florida conditions as was possible with suitable control over results. Nothing was attempted which could not be successfully carried out by any stockholder in Florida with sufficient intelligence to utilize the established principles of animal nutrition and sufficient interest in his business to adopt common business methods.

METHOD OF CARE AND FEEDING.—The animals were confined in the pens described, but were let into the yard twice a day for water and additional exercise. They were fed twice daily; namely, at 7 A. M. and 5 P. M. Their rations were computed so that little waste or unconsumed food was expected; yet it was intended that when hay formed a part of the ration it should be always before them in the feeding racks. The quantity discarded from each ration was carefully weighed and deducted from the quantity of food charged against each lot of steers. The amounts of food thus wasted are not enumerated in the present record and are not charged against the steers fed, as this was not a natural expense of normal feeding, but was one of the incidents of experiment. The steers were watered at 7 A. M. and 4 P. M., the water supplied being spring water. They were weighed every ten days during the feeding period, and the amount of food was varied with the variation in the weight of the steers, so that the quantity of food consumed bore a standard relation to the live weight of the animals fed upon each ration. The rations were carefully weighed at each time of feeding, the writer being personally present as a rule at one or both feedings daily, and making constant check weighings to verify the accuracy of the work. Each individual animal was weighed separately, but the rations were compounded for the different lots, as circumstances did not admit of individual feeding of each steer in the different lots.

PLAN OF EXPERIMENT.—It was intended that each lot of steers should be fed, in proportion to its live weight, exactly the same quantity and proportion of each nutrient. In other words, every steer was to receive exactly the same form and quantity of nutriment, the only difference being that the *source of supply* of fattening material was to be different for each lot of steers. This condition was strictly true of Lots I, III, and IV, but with Lot II it could not be absolutely complied with by using the ration desired. That is, it was not possible by the use of cotton-seed hulls and meal alone to compound a ration absolutely identical with the balanced rations furnished the other lots. The difference, however, was comparatively slight, and by using this ration for one lot of steers opportunity was furnished for comparing the recognized standard ration of the South with the other rations fed. The four lots of steers were given rations in which the predominating constituent, or really the material being tested was as follows: Lot I cassava; Lot II cotton-seed products; Lot III corn meal; Lot IV grade steers as compared with natives. The total feeding time was divided into three different periods, during each of which the standard ration, respectively for the first, second and third periods, was fed. The steers, however, were weighed every ten days, and the actual amount of food fed was varied with the live weight of the animals consuming the ration. The rations fed were as follows:

RATIONS FED.

LOT I.

Per 1000 Pounds Live Weight.

	Pounds.	Nutritive Matter.	Protein.	Carbo-hydrates.	Fats.
Hay	9	4.380	.691	3.569	.116
Cotton-seed meal	5	3.589	1.681	1.152	.480
Cassava*	36	8.391	.133	10.098	.072
Total	50	16.360	2.505	14.819	.668

Ratio, 1:6.5.

LOT II.

Per 1000 Pounds Live Weight.

	Pounds.	Nutritive Matter.	Protein.	Carbo-hydrates.	Fats.
Cotton-seed hulls	30	....	.732	9.696	.696
Cotton-seed meal	6	....	2.017	1.382	.576
Total	36	15.18	2.749	11.078	1.272

Ratio, 1:5.18.†

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* The digestibility of cassava in lieu of actual digestion coefficients was based on the digestibility of Irish potatoes.

† It is probable that the actual nutritive ratio of this ration is wider than appears from the accepted digestion coefficients of the constituents of its two ingredients, inasmuch as experiment has shown, as recorded in the North Carolina Experiment Station Bulletin 92, page 122, that the digestibility of the protein in the cotton-seed meal is retarded by the carbo-hydrates of the hulls.

LOT III.

Per 1000 Pounds Live Weight.

	Pounds.	Nutritive Matter.	Protein.	Carbo-hydrates.	Fats.
Hay*..	3	6.329	.998	5.155	.167
Hulls..	7	2.545	.170	2.252	.172
Bran..	8	4.152	.956	2.947	.224
Corn meal..	7	4.996	.372	4 141	.252
Total..	25	18.022	2.496	14.495	.815

Ratio, 1:6.5.

LOT IV.

Same as Lot I, per 1000 pounds live weight.

The actual amount and cost of the food fed to the different lots of steers for the three different feeding periods, after being computed to correspond to the live weight of each lot, was as follows:

QUANTITY AND COST OF DAILY RATIONS.

FIRST PERIOD.

Lot I.

	lbs.	ozs.	Cost of Feed per Day.
Hay..	17	4	6.9 cts.
Cotton-seed meal..	5	8	7.2
Cassava..	68	10	10.2
Total..			24.3 cts.

Lot II.

	lbs.	ozs.	Cost of Feed per Day.
Cotton-seed hulls..	57	6	29.8 cts.
Cotton-seed meal..	11	8	15.1
Total..			44.9 cts.

Lot III.

	lbs.	ozs.	Cost of Feed per Day.
Hay..	24	10	9.8 cts.
Cotton-seed hulls..	12	4	6.3
Wheat bran..	15	4	15.3
Corn meal..	12	4	13.9
Total..			45.3 cts.

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* Hay, where not otherwise specified, was a mixture of crab-grass, beggar-weed and cow-pea.

Lot IV.

Hay	27		10.8 cts.
Cotton-seed meal	15		19.8
Cassava	106	4	15.9
Total			46.5 cts.

Second Period.

Lot I.

Pea-vine hay	23		9.2 cts.
Cotton-seed meal	13		18.1
Cassava	78	12	11.7
Total			39.0 cts.

Lot II.

Cotton-seed meal	17	12	22.4 cts.
Cotton-seed hulls	70	12	36.7
Total			59.1 cts.

Lot III.

Pea-vine hay	30	4	12.1 cts.
Cotton-seed hulls	12		6.2
Wheat bran	21	12	21.7
Corn meal	15		15.8
Total			55.8 cts.

Lot IV.

Pea-vine hay	32	8	13.0 cts.
Cotton-seed meal	19	12	26.0
Cassava	111		16.6
Total			55.6 cts.

Third Period.

Lot I.

Hay	21	8	8.6 cts.
Cotton-seed meal	13	2	17.3
Cassava	78	4	11.7
Total			37.6 cts.

Lot II.

Cotton-seed hulls	72		37.4 cts.
Cotton-seed meal	16	8	21.7
Total			59.1 cts.

Lot III.

Hay	31	8	12.6 cts.
Cotton-seed hulls	15	8	8.0
Wheat bran	18		18.0
Corn meal	15	12	15.8
Total			54.4 cts.

Lot IV.

Hay	29	8	11.8 cts.
Cotton-seed meal	18		23.7
Cassava	111	8	16.7
Total			52.2 cts.

The first and second periods consisted of forty days each. The third period, because of the lateness of the season, was limited to ten days. The full feeding period would have otherwise continued one hundred and twenty days, consisting of three periods of forty days each. The ration above described as constituting the feed of each lot of steers was the actual quantity of food fed for each twenty-four hours. From the final summary, however, the hay rejected by the animals is subtracted. It must be remembered, moreover, that during the entire time of feeding the animals were all weighed every ten days and the rations above described were then recalculated to meet the live-weight requirements of the steers fed, so that the total quantity of food consumed as given in the final summary was not the actual quantity here enumerated multiplied by the number of days in each period, but was corrected or modified, first by the subtraction of discarded hay, and second by the variation in the live weight of the animals, which necessitated a revision of the ration for each ten-day interval. The final summary, therefore, and charges against the different lots, include simply the food actually consumed and not the theoretical ration provided.

FOODS CONSUMED AND GAINS FOR THE DIFFERENT PERIODS.

First Period.

Lot I.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Hay	762	$ 3 04	388	20.30
Cotton-seed meal	423	5 58		
Cassava	1569.5	4 70		
Total		$ 13 32		

Lot II.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Cotton-seed hulls	2516. —12	$ 13 08	450	23.60
Cotton-seed meal	512. —4	6 74		
Total		$ 19 82		

Lot III.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Hay	1010. —8	$ 4 04	272	14.34
Cotton-seed hulls	535	2 98		
Bran	646	6 46		
Corn meal	522	3 94		
Total		$ 17 42		

Lot IV.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Hay	1046	$ 4 18	322	10.92
Cotton-seed meal	723	9 53		
Cassava	4432	6 64		
Total		$ 20 37		

Second Period.

Lot I.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Hay	839	$ 3 35	90	3.92
Cotton-seed meal	550	7 26		
Cassava	920	4 68		
Total		$ 15 29		

Lot II.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Cotton-seed hulls	2830	$ 10 71	48	3,03
Cotton-seed meal	647	8 54		
Total		$ 19 25		
Lot III.				
Hay	1163	$ 4 65	86	3.04
Cotton-seed hulls	480	2 49		
Bran	820	8 20		
Corn meal	600	6 07		
Total		$ 21 41		
Lot IV.				
Hay	1080	$ 4 32	10	0.30
Cotton-seed meal	790	10 42		
Cassava	4440	6 66		
Total		$ 21 40		

THIRD PERIOD.

Lot I.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Hay	192	$ 76	— 5	
Cotton-seed meal	131	1 72		
Cassava	391	58		
Total		$ 3 06		
Lot II.				
Cotton-seed hulls	720	$ 3 74	— 4	
Cotton-seed meal	165	2 17		
Total		$ 5 91		
Lot III.				
Hay	135	$ 54	26	1.10
Cotton-seed hulls	155	79		
Bran	180	1 80		
Corn meal	157	1 60		
Total		$ 4 73		

Lot IV.

	Amount Consumed.	Cost.	Gain in Live Weight.	Per Cent. Gain.
Hay	140	$ 56	26	0.79
Cotton-seed meal	180	2 37		
Cassava	115	1 67		
Total		$ 4 60		

It takes but a cursory glance at the figures in the above table to show that profitable feeding ceased during the second period, and that there came a time when the cost of the food consumed by the steers exceeded the market value of the live-weight gain. This is always the case when animals are kept beyond a certain point in their fattening process, but are still fed expensive fattening rations. The demonstration of this fact was an essential feature of the experiment. From the constant weighings of the animals we knew ,within a very few days, exactly when the feeding was no longer profitable; and had the animals been fed simply for profit, they would have been marketed when this point was reached, with very great advantage so far as pecuniary results were concerned. It was desired, however, to ascertain the length and lateness of season which would admit of profitable feeding, and, therefore, the experiment was continued until these points were demonstrated, although the financial loss from so doing was fully understood. The exact bearing of these points, however, and the facts demonstrated by this portion of the experiment are best shown by the detailed record of the different weighings of the animals, showing the fluctuations in weight and the actual time when profitable increase in weight came to an end.

RECORD OF WEIGHINGS.

Lot I.

Steer No.	No. of Weighing.	Live Weight.	Gain or Loss per Head.	Gain or Loss per Lot.
10	1	680		
11	1	602		
12	1	624		
10	2	710	30	
11	2	640	78	
12	2	634	10	118
12	3	662	28	
11	3	652	12	
10	3	748	38	78
12	4	676	14	
11	4	695	43	
10	4	776	28	85
12	5	726	50	
11	5	746	51	
10	5	822	46	147
12	6	738	12	
11	6	736	—10	
10	6	778	—44	—42
12	7	744	6	
11	7	779	43	
10	7	818	40	89
12	8	741	—3	
11	8	828	49	
10	8	850	32	78
12	9	744	3	
11	9	793	—35	
10	9	852	2	—30
12	10	728	—16	
11	10	832	—20	
10	10	824	31	— 5

Lot II.

Steer No.	No. of Weighing.	Live Weight.	Gain or Loss per Head.	Gain or Loss per Lot.
1	1	604		
8	1	628		
5	1	674		
1	2	634	30	
8	2	628	0	112
5	2	756	82	
1	3	634	30	
8	3	674	46	116
5	3	796	40	
1	4	620	—14	
8	4	716	32	37

Lot II—Continued.

Steer No.	No. of Weighing.	Live Weight.	Gain or Loss per Head.	Gain or Loss per Lot.
5	4	815	19	
1	5	714	94	
8	5	746	30	202
5	5	896	81	
1	6	694	—20	
8	6	744	— 2	—32
5	6	886	—10	
1	7	676	—18	
8	7	751	7	—26
5	7	871	—15	
1	8	692	16	
8	8	782	31	116
5	8	940	69	
1	9	706	14	
8	9	764	—18	—10
5	9	934	— 6	
1	10	708	2	
8	10	748	—16	--4
5	10	944	10	

Lot III.

Steer No.	No. of Weighing.	Live Weight.	Gain or Loss per Head.	Gain or Loss per Lot.
3	1	592		
9	1	688		
4	1	616		
3	2	636	44	
9	2	740	52	152
4	2	674	58	
3	3	550	—86	
9	3	748	8	—82
4	3	670	— 4	
3	4	552	2	
9	4	760	12	26
4	4	682	12	
3	5	612	60	
9	5	806	46	174
4	5	750	68	
3	6	604	— 8	
9	6	802	— 4	00
4	6	762	12	
3	7	632	28	
9	7	808	6	40
4	7	744	—18	
3	8	662	30	
9	8	836	28	120
4	8	806	62	

LOT III—Continued.

Steer No	No. of Weighing.	Live Weight.	Gain or Loss per Head.	Gain or Loss per Lot.
3	9	672	10	
9	9	804	—32	—50
4	9	778	—28	
3	10	666	— 8	
9	10	822	18	
4	10	794	16	26
		LOT IV.		
2	1	1148		
6	1	840		
7	1	960		
2	2	1210	62	
6	2	862	22	134
7	2	1010	50	
2	3	1228	18	
6	3	894	32	66
7	3	976	16	
2	4	1232	4	
6	4	908	12	68
7	4	1028	52	
2	5	1324	92	
6	5	942	34	102
7	5	1004	—24	
2	6	1280	—44	
6	6	888	—74	—134
7	6	1014	—14	
2	7	1262	—18	
6	7	914	32	14
7	7	1014	0	
2	8	1348	86	
6	8	940	26	134
7	8	1034	20	
2	9	1312	—36	
6	9	942	2	—42
7	9	1026	— 8	
2	10	1310	— 2	
6	10	952	10	26
7	10	1044	18	

Examination of the above record of weighing shows that, although there was more or less fluctuation in the weights of the animals, there was as a whole a constant gain in live weight sufficient to more than compensate for the food consumed up till the ninth weighing, after which there was considerable falling off in gains, and even frequent losses in weight with all the different lots, so that the eighth weighing may be accepted as the last one showing a profitable increase in weight. As the weighings were made at ten-day intervals, the eighth weighing was at the end of seventy days of feeding, the first weighing having been made at the beginning of the feeding period. It may, therefore, be accepted as demonstrated that, for steers in the condition of the animals under experiment, the feeding of which did not begin until mid-winter, a seventy-day feeding period carries the animals to the point of maximum gain and profit. Probably for animals taken directly from the range a ninety-day feeding period would show the greatest profit. On this point the experiments indicate that after the animal has become accustomed to his feed and is, therefore, placed on full feed, an interval of from sixty to seventy-five days is sufficient to bring him to the point where his slaughtering would result in greatest profit to the feeder. This is a consideration of very great importance, and is contrary to the accepted practice among northern feeders, where 120 days upon full feed is usually accepted as the minimum time for securing best results.

It therefore seems that the time during which an animal must be fed in order to be finished off for market with greatest profit is probably at least one-third less than is required for accomplishing the same results in the beef-producing sections of the North. In other words, the Florida feeder is obliged to feed for a very much less time than is the northern feeder, and therefore, other things being equal, he possesses this very great advantage over stock-feeders elsewhere. Accepting the fact that seventy days covered the period of profitable feeding of the steers in question, and that their subsequent feeding was for experimental purposes solely, and that at the end of seventy days they should have been slaughtered, if profit was the sole object of their feeding and they had been in the hands of the average Florida stock-owner under similar conditions, it is important that we study the financial side of the experiment; that is, the cost of the feeding and the returns from the same for this period.

The quantity of food consumed has already been recorded and is known. The basis adopted for estimating the cost of the rations consumed was as follows:

MARKET VALUE OF FOOD CONSUMED.—In determining the value of the different articles entering into the rations fed, the wholesale prices per ton of commercial feed stuffs in Jacksonville with the freight to Lake City added, was accepted as a fair basis, giving results applicable to average Florida conditions. The price of hay was based on the market value of native baled hay, from which the cost of baling, hauling and difference in convenience of handling were deducted, resulting in what was thought would furnish a fair estimate of the value of hay on the farm. The value of the cassava fed was estimated at half-way between our estimate of the actual cost of production and the market value delivered on board cars for starch manufacture, an average allowance of one dollar per ton being made for hauling to the cars. Upon the foregoing basis the value of the different articles fed was as follows:

Hay	$ 8 00	per ton
Cassava	3 00	" "
Cotton-seed hulls	10 50	" "
Cotton-seed meal	26 50	" "
Wheat bran	20 00	" "
Corn meal	20 50	" "

Upon the above basis it is important to next present in form for comparison the relative cost of the different rations fed. The actual cost of the different rations has already been discussed by itself. The relative cost of the amount of food furnished in the different rations, as obtained from the different materials utilized, is here presented.

RELATIVE COST OF RATIONS FED.

Cassava Ration. Lot.	Period.	Cost per Day Per 1000 lbs. Live Weight.	Average.
I.	1st	$0.09	
I.	2d	.12	
I.	3d	.11	11 cents.
Cotton-Seed Ration.			
II.	1st	$0.21	
II.	2d	.24	
II.	3d	.24	23 cents.
Corn Ration.			
III.	1st	$0.23	
III.	2d	.27	
III.	3d	.26	25.3 cents.
Beef Steers.			
IV.	1st	$0.15	
IV.	2d	.17	
IV.	3d	.15	13.6 cents.*

Before considering the final results of the slaughter test and studying the financial results of the experiments, it is necessary that the actual live-weight gains for the seventy-day interval, accepted as the period of maximum profit, be considered, that the data pertaining to the actual increase in weight as the result of the feeding be made available.

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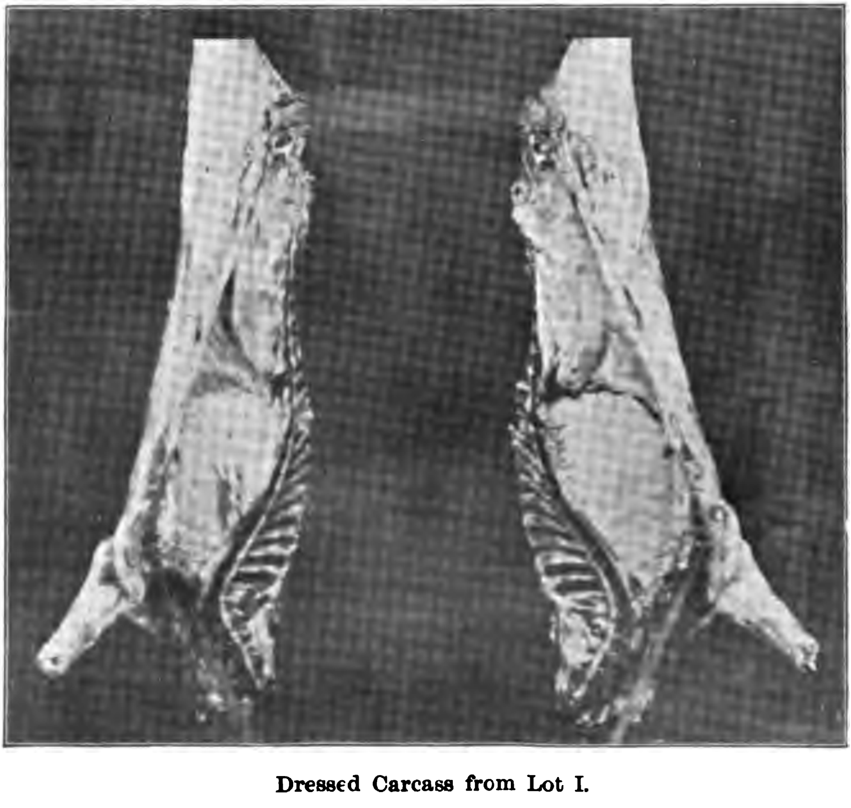
* Lots I and II were fed exactly the same rations per 1000 pounds of live weight, and, therefore, theoretically the cost of the ration should have been the same for each lot. The cost, however, is not based on the food fed, but upon the actual quantity consumed, which fact explains the slight difference in the relative cost of the rations for these two lots.

LIVE-WEIGHT GAINS FOR 70-DAY PERIOD.

Gain per Lot.	Per Cent. of Gain.	Daily Gain per Head.
	LOT I.	
513 lbs.	26.86	2.43 lbs.
	LOT II.	
508 lbs.	26.66 lbs.	2.41 lbs.
	LOT III.	
408 lbs.	21.52	1. 95 lbs.
	LOT IV.	
384 lbs.	18.02 lbs.	1.83 lbs.

The facts presented in the above table require a few words of comment or explanation, that their actual bearing upon the results of the experiments may be fully understood. Mere casual observation might lead to the supposition that the actual gain in weight, either per lot or per head, was comparatively small, and that, therefore, the feeding resulted in comparatively small gains as returns upon the cost of the food consumed. Upon this point it must be remembered that the actual gross increase in weight is not the basis upon which the degree of success of the result of the feeding depends. The actual number of pounds of increase does not tell the story. The proportion or percentage of increase is the true basis for comparison. In Lot 1, for instance, 513 pounds gross gain or increase in weight for three animals for seventy days' time might not be exceptionally large; so also in the same lot an average gain in weight of 2.43 pounds per head per day might inadvertently be considered comparatively small. Both of these suppositions or conclusions would be correct in the case of large, heavy steers weighing 1200 pounds or more. It must, however, be remembered that we were feeding small native steers; that the average weight of the steers in Lot 1 at the beginning of the experiment was only 635



Dressed Carcass from Lot I.

pounds, and that, therefore, the actual gain of 2.43 pounds per day was gratifyingly large. The percentage of gain, therefore, is the true basis of comparison and furnishes actual means for showing the relative gains made by the different lots in this experiment, as well as for comparison with results obtained elsewhere.

SLAUGHTERING TEST.—Having now presented the matter of the live-weight gains of the steers in the different lots, it is necessary to consider briefly the actual results of the slaughtering of the animals. It was not possible to slaughter all the animals at one time, inasmuch as the available market could not utilize so large a quantity of beef at one time. Moreover, the conditions under which the beef was sold, which included the reservation of certain parts for experimental purposes, and the utilization of a considerable portion of the beef in the College mess hall, necessitated sale considerably below the maximum market price of such beef, so that the final estimate of profit and loss is necessarily made upon a live-weight rather than a dressed-weight basis. From a practical standpoint, however, as this meets the actual condition of sale with most Florida feeders, these circumstances were probably no disadvantage. The animals were slaughtered three at a time, one steer from each of the first three lots, and the three steers from Lot IV made a single slaughtering by themselves. The killing was all done by the same butchers at the same time of day, and with identical preliminary treatment, so that the comparisons and results as to relations between live-weight and dressed-weight furnish no variation or inequality.

PERCENTAGE OF DRESSED WEIGHT.*

LOT I.

No.	Live Weight.	Dressed Weight.	Per cent. of Dressed Meat.
10	824	479	57.57
11	814	441	54.19
12	728	412	56.86
		Average......	56.23

LOT II.

No.	Live Weight.	Dressed Weight.	Per cent. of Dressed Meat.
5	944	449	54.62
8	698	395	56.59
1	710	372	52.49
		Average......	54.55

LOT III.

No.	Live Weight.	Dressed Weight.	Per cent. of Dressed Meat.
9	822	449	54.62
4	798	430	53.88
3	678	380	53.44
		Average......	54.31

LOT IV.

No.	Live Weight.	Dressed Weight.	Per cent. of Dressed Meat.
2	1338	778	58.15
6	984	526	53.45
7	1070	596	55.70
		Average......	55.78

The mere gain in weight or percentage of waste, as determined by slaughtering, does not necessarily prove the relative value of different carcasses, which must depend to a considerable degree upon the location of the better or higher priced meats. In our experiments no effort was made to separate the different portions of the carcass, except so far as the quarters were concerned. These weights, however, furnish information as to the position of the heaviest portion of the carcass as follows:

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*Animals were deprived of food and water for sixteen hours previous to slaughtering.

Lot I.

No.	Fore Quarter.	Hind Quarter.	Percentage of Hind Quarters.
10	130	111	46.36
	128	110	
11	116	103	
	116	106	
12	113	94	
	111	94	
Totals	715	618	

Lot II.

5	130	124	49.39
	130	126	
8	114	100	
	102	92	
1	97	90	
	99	80	
Totals	676	618	

Lot III.

9	115	110	48.10
	115	109	
4	106	195	
	114	102	
3	98	92	
	98	92	
Totals	642	595	

Lot IV.

2	208	184	46.78
	202	184	
7	166	136	
	156	138	
6	140	123	
	139	124	
Totals	1011	889	

QUALITY OF THE BEEF PRODUCED.—The mere fact of the economical production of beef, if established, was not sufficient for the object in view, since the quality of the product, and consequently its position in the market, was considered as of equal importance.

Meat from all of the different lots was placed on sale in the Lake City market in competition with Chicago dressed beef, and was retailed at the same price demanded for the latter. It is an important and gratifying fact that while the Station beef was available, it was demanded in preference to Chicago beef and that during the two weeks while it was available, Western beef was entirely excluded from our market. This fact would seem to demonstrate that the quality of Florida fat beef is equal to that of the best produced elsewhere.

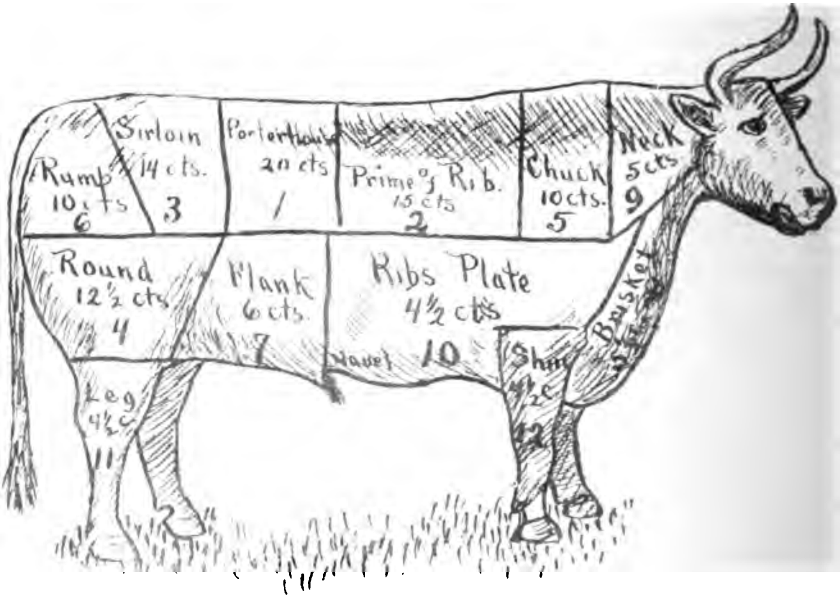
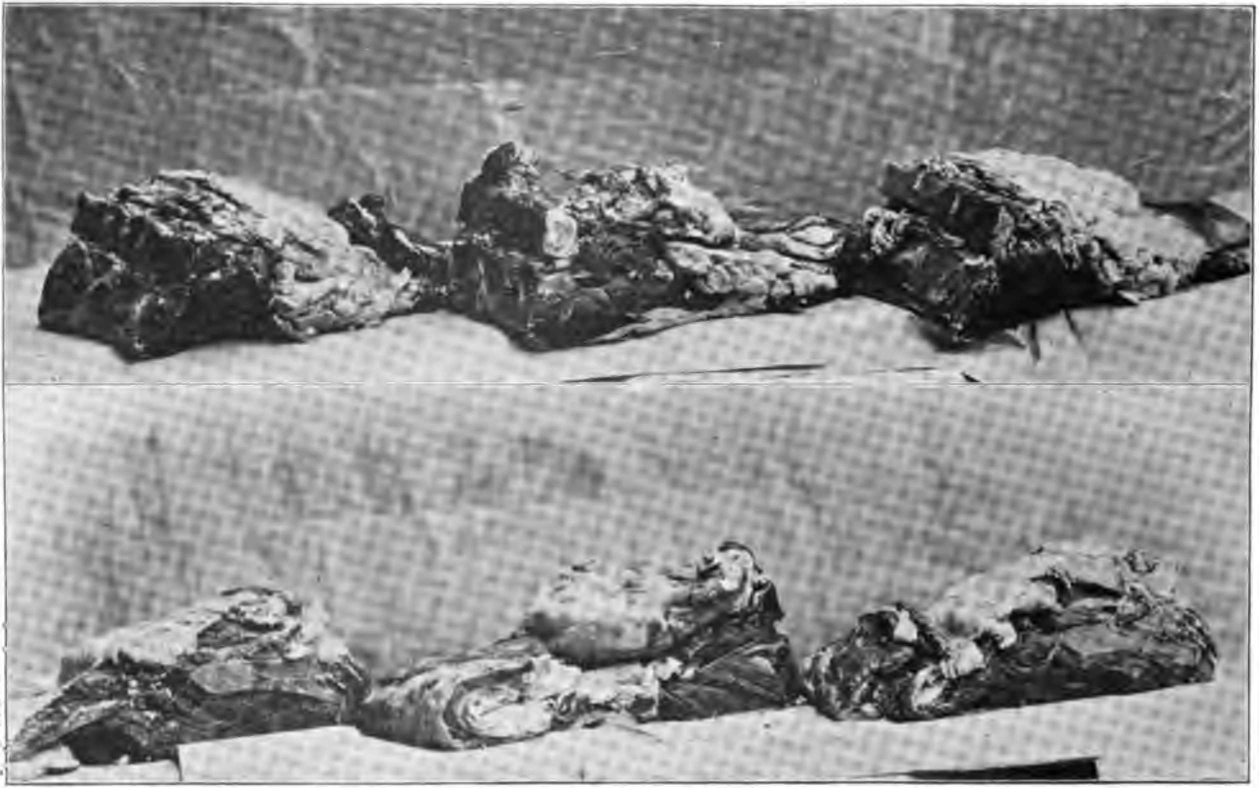
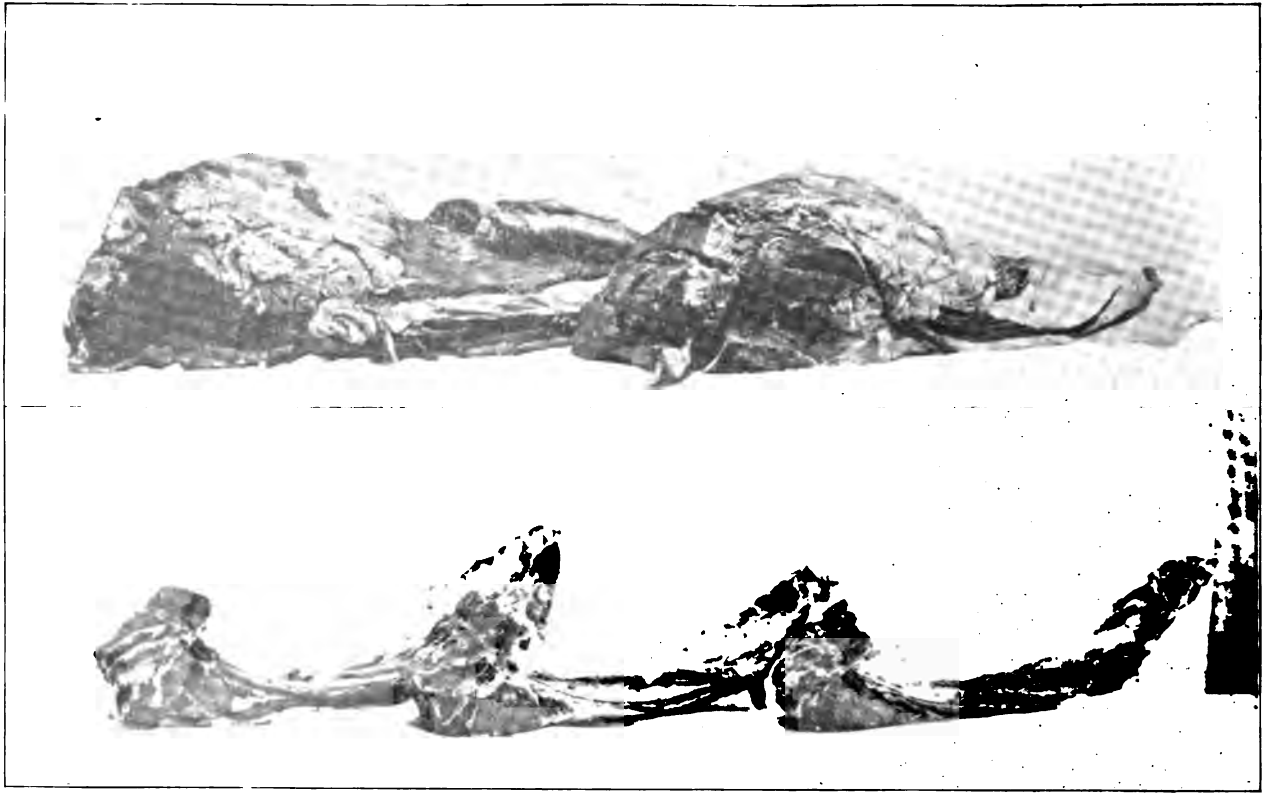


Diagram Showing Location and Relative Value of Different Cuts of Beef.

For the purpose of establishing the relative merits of the beef produced from the feeding of the different rations used, and consequently the comparative value of the different rations as affecting the quality of product, samples of beef from each lot were sent to three unbiased persons, who were requested to make comparative table tests of the different samples and to



"Porter House" Cuts from Lots I, II and III—
Cassava—Cotton-seed Products—Corn.
Corn—Cotton-seed Products—Cassava.



"Porter House" Cuts from Lot IV.
Rib Roasts—Lot I, Lot II, Lot III.

mark them as to relative superiority, being meanwhile ignorant of the origin of the different samples. The result of the test was that in every case by all three judges the beef of Lot No. I, fed on cassava, was marked first choice, while Lots Nos. 3 and 2, fed upon corn meal and cotton-seed products, respectively, were given second and third choice. This judgment was demonstrated as meeting practical approval in the market, where purchasers invariably called for the cassava fed beef and preferred the same in preference to that from the other two lots whenever it was available. It would seem, therefore, that not only is the possibility of profitable beef production with native stock and feed stuffs established, but furthermore, that the quality of the product thus produced ranks as first-class and can be successfully sold in competition with the best corn-fed product, which is the accepted American standard of excellence.

FINANCIAL RESULTS.—The experiment itself having been finished and two of the four questions under consideration having been answered, namely, *first*, that native steers could be fed profitably upon Florida feed stuffs, and *second*, that the seventy-day period of feeding gave the most profitable returns, the results of the experiment must be examined individually from a financial standpoint, that the actual degree of profit may be learned, and further, that the two other questions under consideration, namely, the relative profit from the feeding of different rations and the comparative merit of native and grade steers may be presented. The seventy-day period already considered and the live-weight basis of value for the finished product were adopted. The matter of the basis for determining the value of the beef produced was presented to Messrs. Hart & Co., of Jacksonville, from whom the steers were originally purchased. They are the largest feeders and slaughterers of cattle in Florida, their slaughtering for the Jacksonville market amounting annually to nearly 4,000 head. They suggested two bases for estimating the increased value of the animals as the result of feeding. *First,* an estimate of 5c per pound upon the actual increase in weight, this estimate being based upon the well-known fact that a fat animal not only consists of a greater weight of meat than the same animal in an unfattened condition, but that the quality of the meat of the entire carcass is so improved by the fattening process that the value of the original weight of the carcass is increased by the feeding. *Second,* an estimate of 3 5-8c per pound as the actual market value of the animals on a live-weight basis. As Messrs. Hart & Co. actually offered this price for the animals delivered in Jacksonville, this second basis was adopted as the real value of the animals and the fairest possible basis for determining the financial results of feeding the steers.*

FINANCIAL STATEMENT ON LIVE-WEIGHT BASIS.

Lot.	Original Weight.	Final Weight.	Increase.	Cost.	Final Value.	Cost of Feed.	Increased Value Over Cost of Feed.	Profit Over Total Cost of Steers and Feed.	Profit per Head.	PerCentProfit on Cost of Steers.	Total per Cent. Profit on Investment.
	lbs.	lbs.	lbs	$	$	$					
I	1906	2419	513	38.12	87.62	21.25	$66.37	$28.75	$9.58	75.41	48.42
II	1905	2414	508	38.12	87.42	25.49	61.73	23.81	7.93	62.43	37,43
III	1896	2304	408	37.92	83.52	34.03	49.49	11.57	3.85	30.54	14.69
IV	2948	3322	384	58.96	120.41	36.04	84.37	25.41	8.47	43.09	26.73

The above table of the financial results of the feeding presents in graphic form several facts of such importance that detailed consideration seems necessary. The basis on which the estimate of cost and value of the animals is that furnished by Messrs. Hart & Co. of Jacksonville, the original value placed on the steers at 2 cents per pound live weight is the actual cost of the animals delivered in Jacksonville. The value of the finished animals, estimated at 3 5-8 cents per pound, is the market value of the steers when slaughtered, and the price offered for the same by Messrs. Hart & Co. It is believed that for small numbers local markets are fully as good as the Jacksonville market. For large numbers, however, the cost of transporting the fattened steers to Jacksonville would necessarily be deducted from the estimated profits. In car-load lots for average Florida points this cost of transportation would not exceed 75 cents per head; as it varies from different places, however, and in many cases would not be necessary at all, this point has not been considered in my estimation of the financial results of fattening. As a prime object of the experiments was a comparison of different Florida feed stuffs, the point demanding first attention is that of the relative results shown from the feeding of the different rations used. The four different lots show profits over and above the cost of the steers and the cost of the feed consumed for the respective lots as follows: I, $28.75; II, $23.81; III, $11.57; IV, $25.41. The important point demonstrated by these figures is the fact that cassava as a profitable ration stands at the head of the list, with a profit of $4.94 in excess of that obtained from the feeding of the same number of animals on the cotton-seed ration, and $17.18 more than resulted from the feeding of corn. In this connection, as the single animal is the proper unit for estimating profits and costs, it will be noticed that the average cost of the native steers per head is

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*The value of the manure produced is allowed to off-set the care of the animals. The actual manurial value of the food consumed is sufficiently important and complicated a matter to receive more extended consideration than was deemed advisable here.

$12.68. It seems, therefore, that the profit of feeding a single animal on cassava is $9.58, upon cotton seed mixture $7.93, and upon corn $3.85. There is nothing exceptional in this showing to people actually familiar with the possibilities of stock feeding in Florida. Messrs. Hart & Co., at the time the feeding of these steers began, prophesied that their feeding would result in a profit of from $7 to $10 per head. How close this estimate came to the actual fact in the case of the cassava and cotton-seed lots is easily apparent.*

The actual profit on the feeding of the cassava steers was 48.42 per cent. on the investment. The cotton-seed steers returned a profit of 37.43 per cent. and the corn-fed steers 14.98 per cent. The difference between Lots I and II is decidedly apparent and shows cassava to be very materially the cheapest and best ration which can be used for fattening purposes. The most astonishing fact, however, is the very great difference demonstrated between the cost and the results of feeding corn and feeding cassava, the difference being almost two-thirds in favor of the latter. Before proceeding to a further consideration and application of the results thus demonstrated, the fact should be briefly noticed that Lot IV showed a comparatively small profit and a comparatively high cost of feeding, as compared with Lot I, although both lots were given the same ration. I believe, however, that the result is easily explained and is not adverse to the advantage of the introduction of better blood into our herds of range cattle. I interpret the

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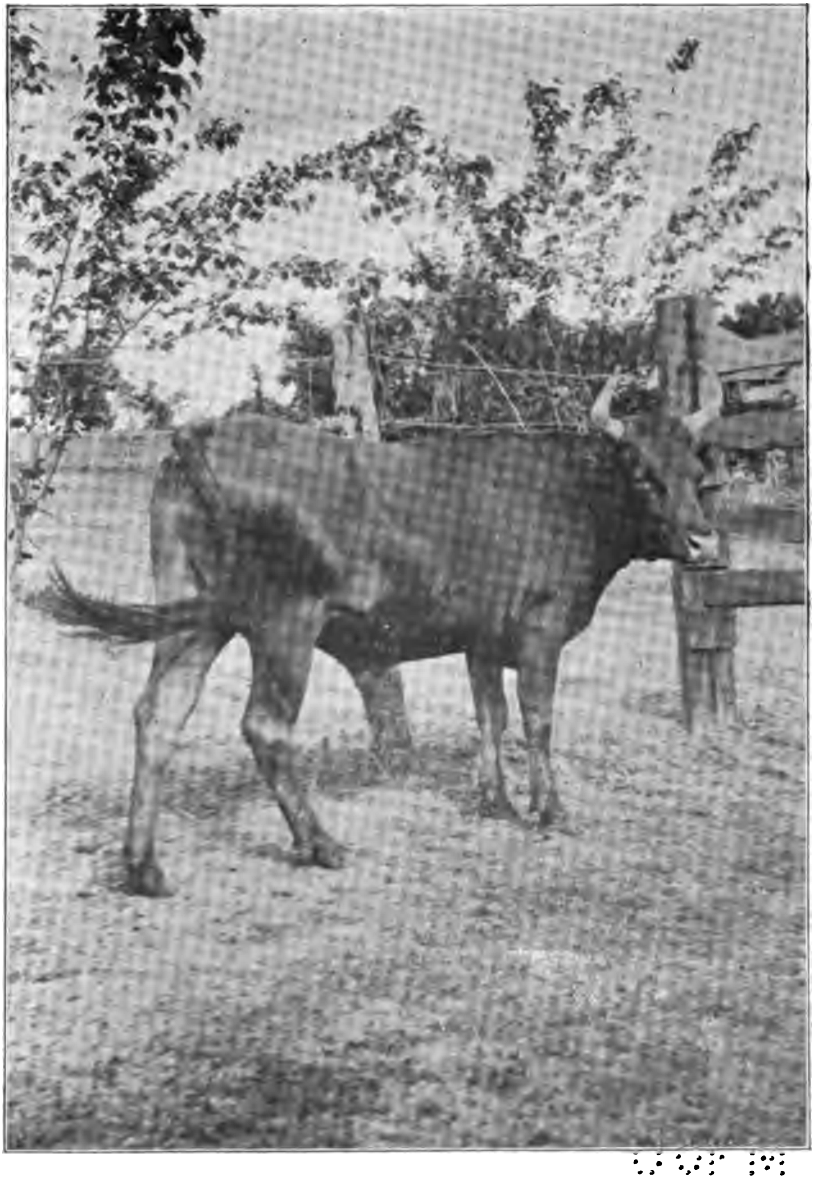
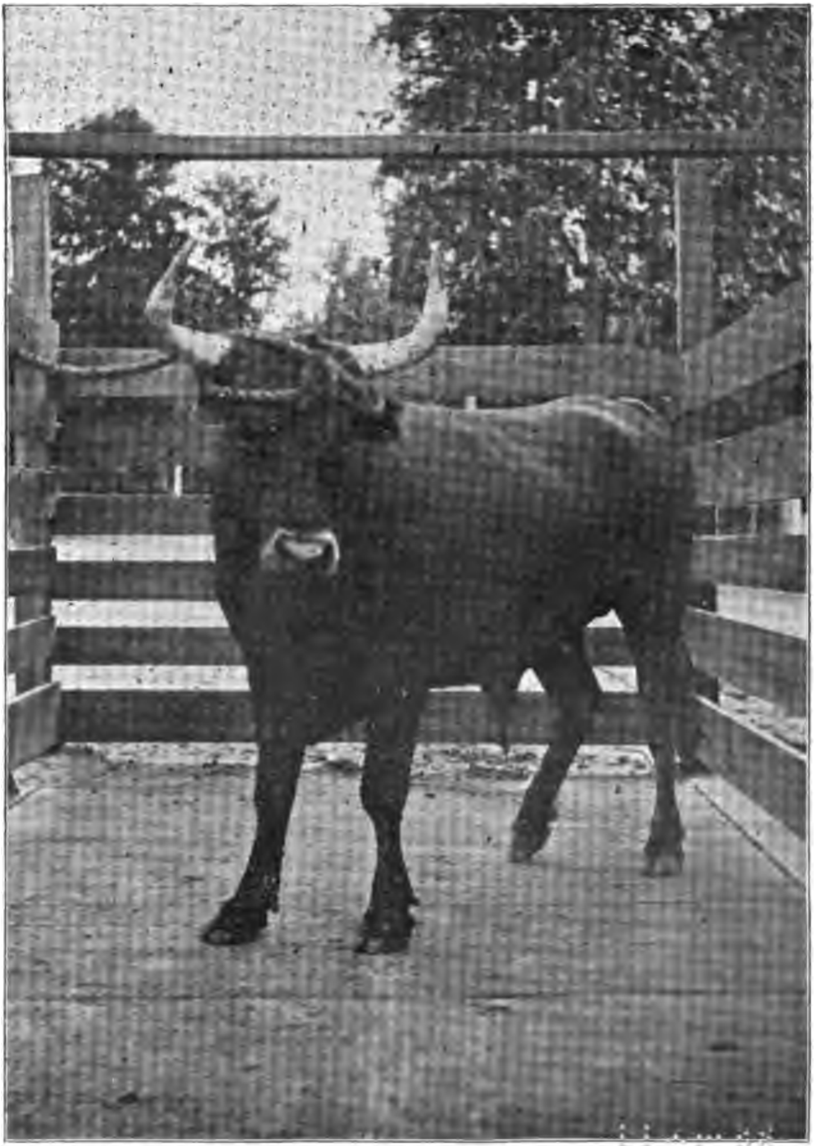
* Mr. O. J. Hill, of DeLand, has kindly placed at my disposal the data secured by him from feeding 113 head of native steers last winter on cassava and one small feed of corn in the ear daily. These steers had access to a small supply of standing corn fodder and wire-grass for roughage. The steers were marketed as fat beef in DeLand, and showed a handsome profit on cost and expenses.



Steer No. 10, Lot I.



Steer No. 5, Lot II.

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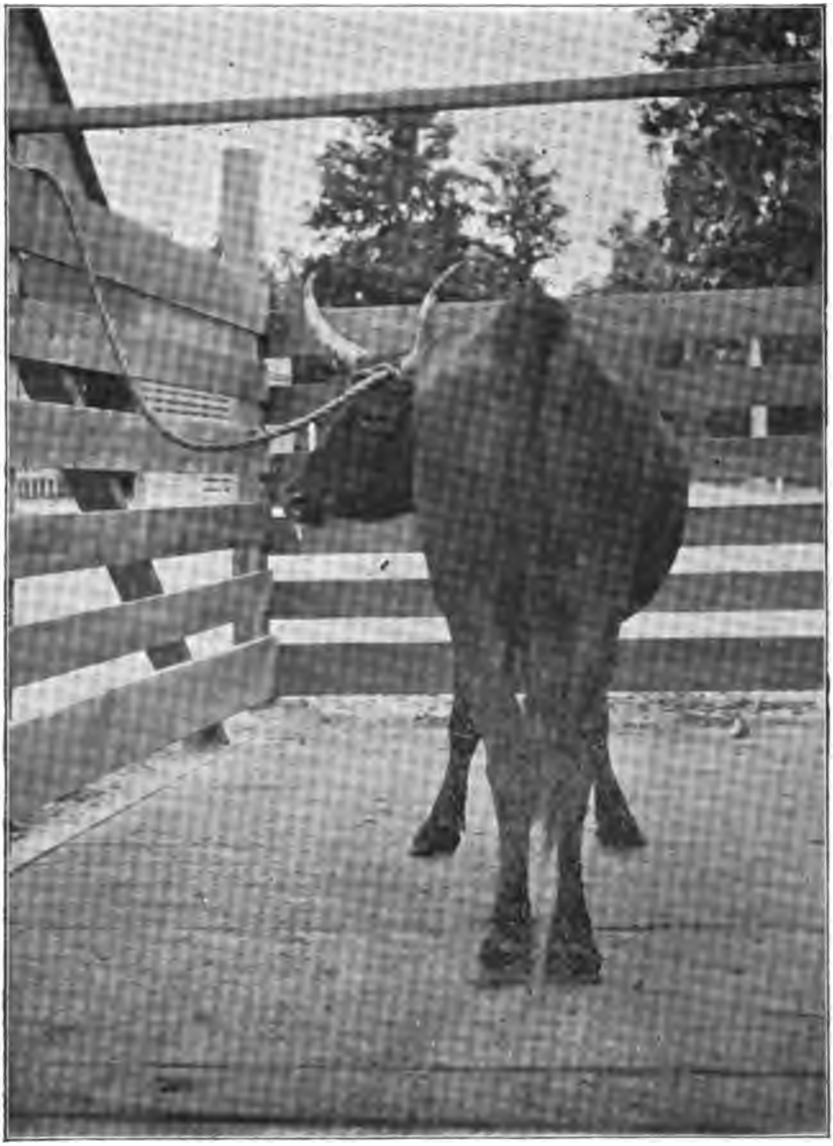

Steer No. 9, Lot III.

MYoU

result as simply showing that Lot IV, from its natural propensity to take on fat, made proportionately a larger gain during the short interval of preliminary feeding in Jacksonville and after they had been brought to the station, so that when the actual experimental feeding began these beef steers were more nearly finished, and that, therefore, they afterwards took on a smaller proportion of increased weight and show correspondingly small gains and profits.

Relative Per Cent. of Profit.—In the last column of the foregoing table the total percentage of profit on the investment resulting from the feeding of the four different lots of steers is presented as follows: I, 48.42 per cent.; II, 37.43 per cent.; III, 14.69 per cent.; IV, 26.73 per cent. These data, as well as the actual profits recorded per head, in which Lot I stands at $9.58 as against $3.85 for Lot III, give abundant evidence of the actual relative profits of the different rations fed. For convenience of comparison, however, and as an actual measure of the relation between the success of the different rations, it is best to accept the results obtained with Lot No. I, fed on the cassava ration, which heads the list in profits returned as 100, and on this basis compare the results in each other case upon this same scale. By this means, we have the following results:

Cassava	100
Cotton-seed ration	77.53
Corn-meal ration	29.79
Grade steers	55.40

On the same basis, therefore, the cotton-seed meal and hulls ration returned a profit of 77.53 per cent. of that from the cassava ration, the corn-meal ration 29.79 per cent., and the grade steers 55.41 per cent. The relative or comparative value of the three different rations, and the grade steers, as compared with the native, are thus graphically presented, and require no further comment.

The questions propounded at the beginning of the investigation, viz.: "Can native Florida steers be fed at a profit?" "What is the most profitable ration of Florida feed stuffs?" "What is the most profitable length of feeding period?" and "Do grade steers give better results than natives?" have been answered so far as this inquiry is concerned.

It, therefore, remains simply to apply the results secured, and make such comparisons as seem applicable as further demonstrating the bearing of the results.

THE MOST PROFITABLE RATION.—As the determination of this point was one of the chief objects of the experiment, the bearing of the data before recorded upon the question of the relative economy of the different rations fed should now be collated for reference and convenient consideration. In this connection it should be remembered that no ration used was as economical as could have been arranged with Florida feedstuffs. Velvet beans in forage and ground as meal furnish the cheapest source of proteins, and would have given far more profitable returns. Their composition is, however, not sufficiently determined to fit them for the purposes of this experiment. It is demonstrated that from every point of consideration the cassava ration furnished the most economical food and returned the greatest net product for the cost involved; that, therefore, the cassava ration, or rations in which cassava forms the predominating carbonaceous constituent, are the most profitable for Florida feeders. The points of superiority, as demonstrated by comparison, are as follows:

	Daily Gain per Head, Lbs.	Per Cent. Gain.	Cost of Ration per 1000 Lbs. Live Weight.	Cost of Beef per Lb.
Lot I.				
Cassava ration	2.43	26.86	11c.	4.14c.
Lot II.				
Cotton-seed product ration.	2.41	26.66	23c.	5c.
Lot III.				
Corn-meal ration	1.95	21.52	25.3c.	8.34c.

The cassava ration being demonstrated to be the most profitable ration used, and, therefore, to be the best ration for Florida purposes, it may be accepted for the present as a standard Florida ration, and as such used for the purpose of comparing the results thus obtained in Florida with those obtained under similar conditions elsewhere.

Some Comparisons.—The degree of success in the fattening of beef in Florida can be best measured by actual comparison with typical results secured in sections of the county recognized as beef-producing sections, in which the fattening of cattle is successfully practiced for profit.

COMPARISONS.

	Average Weight of Steers at Beginning.	Daily Gain per Head.	Cost of Gain per Lb.
Texas	616 lbs.	1.97 lbs.	5.99c.
Florida	635 lbs.	2.43 lbs.	4.14c.

	Length of Period.	Per Cent. Gain in Live Weight.	Daily Gain per Head.	Cost of Gain per Head.
Nebraska	180 days.	22.64	1.26	8.76
Florida	70 days.	26.	2.43	4.14

The above data from Texas are the results of feeding experiments conducted at the Texas Experiment Station and recorded in Bulletin No. 27.* It is an accepted fact that Texas is a great feeding State, that her stock owners grow, fatten and ship hundreds of thousands of head of cattle annually, and that they are in the business for the profit it brings them. By comparison, however, we see that Florida range steers can be as easily fattened as Texas animals, and will in a given time make a gain of 23.35 per cent above Texas animals under identical conditions.

The Nebraska comparison is even more important. The Standard Cattle Co., which owns large ranges in Colorado and Montana, has been engaged for several years in fattening several thousand head of its range steers for the Chicago market upon its own farms at Allen, Nebraska.

It has found this business profitable. For the past eleven years the average number of animals thus taken from the ranges and fattened has been about five thousand head. The careful accounts kept by the company have recently been published in his work on "Feeds and Feeding," by Prof. W. A. Henry.†

By comparison of the results obtained by our own feeding in Florida and those recorded above from Nebraska, the first point presented is the apparent fact that Florida produces a given result in seventy days of feeding, while in Nebraska 180 days and proportional expense are required for corresponding results. Nevertheless, the total percentage of gain in Florida is much greater than in Nebraska, while our average daily gain is nearly double that of Nebraska, and the cost of our beef per pound is less than one-half of that produced in Nebraska.

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*In this comparison the cost is based on present values of feedstuffs.

† "Feeds and Feeding," second edition, Madison, Wisconsin, 1900.

It would seem that, from the facts presented, not only are the possibilities and advantages possessed by Florida for profitable beef production demonstrated, but her superiority is proved over sections of the country where the industry is already established and successful.

III.

EXPERIMENTS WITH HOGS.

Object of the Experiments.—The experimental feeding of hogs was undertaken for the purpose of establishing the relative value of different rations in the fattening of hogs for market. It was believed that the general adaptation of Florida to the production of fat hogs needed no demonstration. It was thought, however, that far better results could be secured if feeding of hogs was followed in accordance with scientific principles. It was believed, moreover, that among the very many hog foods of accepted value some doubtless could be used with greater economy than others, and all could be utilized with greater advantage if compounded into rations more perfectly adapted to the requirements of the animals to be fed.

Character of the Animals.—That the results of the experiments might be applicable to average Florida conditions, the feeding with hogs as with steers was undertaken with native animals. It was desired that the results obtained should be applicable not especially to improved breeds of hogs and the somewhat exceptional conditions under which such animals are maintained in Florida; for the purpose of experiment, therefore, native hogs of the common "razor-back" family were selected. That they might fairly represent this great type, the animals fed were purchased for the purpose from the "flat woods" range and had never been either confined or artificially fed until they were brought to the Station farm.

METHOD OF CARE AND FEEDING.—When first purchased by us these hogs were entirely unaccustomed to any food except such as was secured as a result of their own "rustling." The first step, therefore, in the experiment was to place them upon a preliminary feeding until they became sufficiently accustomed to the different native foods to take rations regularly and thrive thereon. This preliminary feeding continued for twenty days, at the end of which time it was believed the experiment might be successfully undertaken. The animals were then weighed and divided into lots of four each, each lot being placed in a commodious pen without shelter and provided with a constant supply of running water. Their rations were given them in troughs morning and night.

PLAN OF EXPERIMENT.—Essentially the same system was followed with the hogs as before described for the steers. Each lot of native hogs was given a ration apportioned to the live weight of the animals consuming the same. All the different rations were compounded so as to furnish practically identical quantities and proportions of nutriment, the only variation being in the source of supply, and each ration was so proportioned as to furnish the quantity of each constituent and a nutritive ratio conforming to the accepted feeding standard for the class of hogs for which it was prepared. As with the steers, so also with the hogs, in addition to the test of the effect of different rations upon native animals, a comparison of improved stock

Hogs of Lots I and II, Cross-bred and Native.

U of M

with the native was made, for which purpose a lot of four cross-bred Duroc-Jersey Poland-China shoats was selected and given the identical ration fed to the comparable pen of native hogs. The hogs were divided into lots and devoted to the following tests: Lot I, grade hogs as compared with native; Lot II, cassava ration; Lot III, corn ration; Lot IV, sweet-potato ration; Lot V, corn alone. The corn used, wherever fed, was native shelled corn, dry and uncooked.

RATIONS FED.

LOT I.

Per 100 Pounds Live Weight.

	Pounds.	Protein.	Carbo-hydrates.	Fat, Lbs.
Cassava	4	0.002 lbs.	0,996 lbs.	1.000
Wheat middlings	2	0.244 "	0.844 "	0.058
Cow peas	1.5	0.274 "	0.813 "	0.016
Total		0.520 lbs.	2.753 lbs.	0.074

Nutritive ratio, 1 : 5.2.

LOT II.

Per 100 Pounds Live Weight.

Native hogs same ration as Lot I.

LOT III.

Per 100 Pounds Live Weight.

	Pounds.	Protein.	Carbo-hydrates.	Fat, Lbs.
Corn	2	.145 lbs.	1.258 lbs.	.077
Wheat middlings	3	.355 "	.105 "	.184
Total		.500 lbs.	2.363 lbs.	.261

Nutritive ratio, 1 : 5.9

Lot IV.

Per 100 Pounds Live Weight.

	Pounds.	Protein.	Carbo-hydrates.	Fat, Lbs.
Sweet potatoes........	3.5	.031 lbs.	0.777 lbs.	0.010
Wheat middlings......	3.5	.427 "	1.652 "	0.101
Totals.......		0.459 lbs.	2.429 lbs.	0.111

Nutritive ratio 1 : 5.8.

Lot V.

Per 100 Pounds Live Weight.

Fed all the corn the hogs would eat.

	Pounds.	Protein.	Carbo-hydrates.	Fat, Lbs.
Average daily amt. of corn.	6.03	0.379 lbs.	3.907 lbs.	0.301

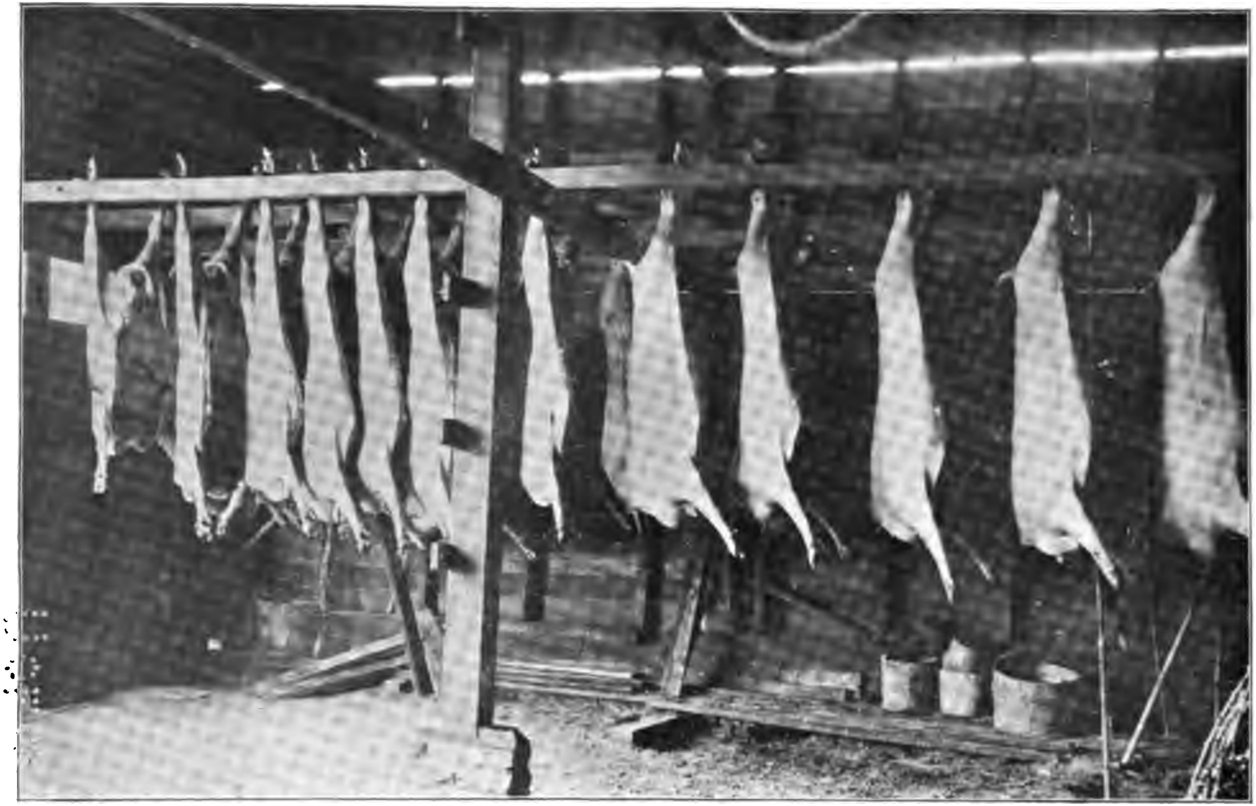
Nutritive ratio, 1 : 10.3.

LIVE-WEIGHT GAINS.

Lot.	No. of Hogs.	First Weight, Lbs.	Last Weight, Lbs.	Gain, Lbs.	Per Cent. of Gain, Lbs.	Feed.
I.	4	526.	817.	291.	55.32	Cross-bred, on cassava ration.
II.	1	86.5	119.	32.5	37.57	Cassava ration.
III.	4	452.	612.	160.	35.39	Corn ration.
IV.	4	406.	533.5	126.5	31.16	Potato ration.
V.	4	381.	484.5	103.5	26.90	Corn alone.

RATIONS FED AND COST OF LIVE-WEIGHT GAINS.

Lot.	Cassava, Lbs.	Wheat Middlings, Lbs.	Peas, Lbs.	Potatoes, Lbs.	Corn, Lbs.	Cost of Ration.	Amount of Gain.	Cost per Lb. of Gain.
I.	946.80	473.40	355.11	....	....	$ 8 64	291.	2.9c.
II.	155.70	77.85	56.38	....	....	2 12	32.5	3.1c.
III.	....	610.20	....	....	406.80	9 13	160.	5.6c.
IV.	....	639.51	....	639.45	....	10 02	126.5	5.6c.
V.	....	....	....	....	1033.84	7 31	103.5	7.0c.



Native Hogs (Lots II, III, IV and V), Killed April 20th, with the Atmospheric Temperature at 84 Degrees, and Cured by Use of 1,000 Pounds of Ice.

The above table shows the actual amount of the different feed stuffs fed to the separate lots of hogs, and consequently shows, in connection with the actual gain in weight, the real cost of the product.

SLAUGHTERING TEST.—On April 20th the hogs were all slaughtered, having been without food for the previous sixteen hours. They were weighed individually immediately before killing, and afterwards on the afternoon of the same day the dressed carcasses were weighed for the purpose of ascertaining the relation between the live and dressed weights. The dressed carcasses, as weighed, were in the ordinary market condition, i. e., the viscera and internal organs were all removed, but the head and feet were not removed. The results of these weighings are presented in the following table:

RELATION BETWEEN LIVE AND DRESSED WEIGHTS.

No.	Live Weight.	Dressed Weight.	Per Cent. of Dressed Weight.
		LOT I.	
1	210.	153.	
2	185.	148 5	
3	197.5	157.5	
4	224.5	174.5	
Total..........	817.0	633.5	77.53
		LOT II.	
1	119.	82.5	69.32
		LOT III.	
1	129.5	85.5	
2	156.5	110.5	
3	158.	116.5	
4	168.	121.0	
Total..........	612.0	433.5	77.51
		LOT IV.	
1	141.	88.	
2	115.	79.	
3	154.5	106.5	
4	123.	86.5	
Total...........	533.5	360.0	67.29

LOT V.

No.	Live Weight.	Dressed Weight.	Per Cent. of Dressed Weight
1	76.	49.	
2	119.	82.5	
3	94.5	58.5	
Total..........	289.5	190.0	65.63

Several facts presented in the above table are worthy of special consideration. Attention, however, is first called to the absence in the enumeration of three hogs from Lot II and one hog from Lot V. Two of these animals were known to be unwell, had been suffering from some chronic disease during the entire latter part of the feeding period, so that, although their feeding was continued, they were excluded from the final test. Two were found to be with pig, and, therefore, were not killed.

Lots I and II, consisting respectively of cross-bred and of native hogs, returned an almost identical percentage of dressed weight.,It is apparent, therefore, that whatever may be the facts concerning the relative fattening propensity, and early maturity of the two different classes of hogs, the native "rasor-back" may be made to return when slaughtered an actual net proportion of meat equal to that of the best fattening breeds. Among the lots of native hogs, the highest percentage of dressed meat was produced by Lot III and the lowest by Lot V, fed respectively upon the corn ration and upon corn alone, a fact which emphasizes very emphatically the advantage of utilizing corn as a constituent of a ration, but the disadvantage of feeding it as an exclusive food for fattening purposes. The returns from Lots I and II furnish additional proof of the fattening propensity of the blooded hog, as compared with the native one fed upon the same ration. These facts, though interesting and important, should be considered in connection with actual cost of the different rations fed, which furnishes the key to the actual financial results of the feeding.

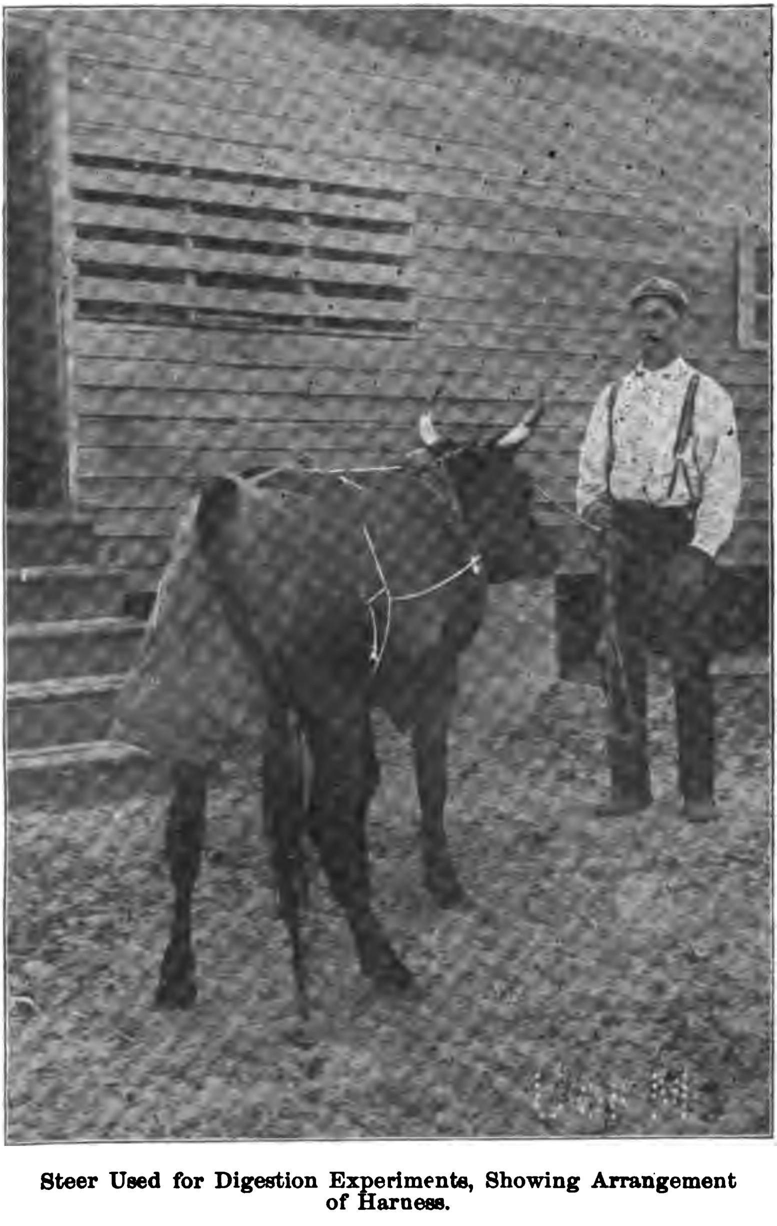
IV.

DETERMINATION OF THE DIGESTIBILITY OF FEEDSTUFFS.

As stated in the introduction, the value of any food or feedstuff does not depend entirely upon its composition, but is determined by the amount or proportion of the different ingredients which are digestible; that is, the value of the food in the animal economy depends not on the material present as shown by analysis, but on the actual amount of nutriment which the animal is able to extract from the food. No animal is able to take up all of any article of food, and the part which is actually assimilated is the digestible portion of the food.

The proportion of any food constituent actually digested by the animal is called the *digestion coefficient* of that food; for instance, of cotton-seed meal 89 per cent. of the protein present is digestible, and, therefore, the digestion coefficient of the protein in cotton-seed meal is 89. The same fact in varying degree is true of every different article of animal consumption, and the digestion coefficients of most feedstuffs have actually been determined, so that in the compounding of rations the part of the food constituents actually digested or utilized by the animal is the portion really considered in arranging the ration and determining the nutritive ratio of the same. The method for determination of the digestion coefficients of different feedstuffs is comparatively simple, although based on strictly scientific principles and necessitating the greatest care in manipulation. The method in brief simply consists in analyzing all of the food an animal eats and all of the refuse or excrement discarded, or excreted, and the difference is the portion actually ulitized, consumed or digested by the animal. The practical details consist in carefully analyzing all the food fed to the animal used for the experiment, and, if a mixed ration is used, incorporating with the same a portion of the article the digestion coefficient of which is to be determined, and then placing the animal in a harness so arranged that all excrement is collected and subjected to analysis, so that the actual amount and proportion of the food eaten and the part excluded can be compared. The difference has been digested, that is, assimilated by the system of the animal.

It so happens that most of the digestion experiments and determinations of digestion coefficients in this country have been conducted by Experiment Stations in the Northern States, where many of the foods used are unlike those common to the South, and, moreover, where Southern feedstuffs are unknown, and, therefore, not available for experimental purposes. The natural result has been that a very considerable number of the more common Southern feedstuffs have not been thus investigated, and that, therefore, the digestion coefficients of many articles fed to animals in the South are unknown, or insufficiently determined. This is true of even so common an article of human and animal food as the sweet potato. The desirability, therefore,'of determining the digestion coefficients of common Southern feedstuffs must be apparent, and this work has been inaugurated by us with the intention of continuation until the actual facts as to the digestibility of all our feedstuffs are established, so that rations for Southern animals may be compounded with the same degree of scientific accuracy as is to-day possible) with the commerical feedstuffs of the North. This investigation has but just begun, and the results of



Steer Used for Digestion Experiments, Showing Arrangement of Harness.

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digestion coefficients with but two feedstuffs, namely, cassava and velvet beans, are incorporated herewith. Other feedstuffs of nearly equal importance, however, such as sweet potato, rice by-products, cow-peas, crab-grass, wire-grass, cow-foot grass and beggar-weed will be subjected to careful inquiry in the near future. It is intended that sheep, as well as steers, be utilized in these experiments, although thus far the work has been confined to a single animal; namely, a two-year-old native steer, whose appearance in harness is shown in the accompanying illustration.

The arrangement of this harness was similar in essential features to that commonly used for similar work, though in simplicity of detail and effectiveness it is believed to be an improvement over any heretofore in use. It consisted of a collar buckled about the neck of the animal and a sack, for the catching and retaining of the excrement, held in place by four cords, one following the line of the back, one the stomach, and one upon each side. There was also a girth surrounding the animal, to assist in holding the different lines in place. The sack itself was made of strong canvas lined with oilcloth, so that it was impervious to moisture. Gatherings of the excrement voided were made four times a day and immediately taken to the laboratory for analysis.

Digestibility of Cassava.—For the purpose of determining the digestibility of cassava the following daily ration was used:

RATION.

	Pounds.	Dry Matter.	Crude Protein.	Carbo-hydrates.	Extract Matter.	Fat.
Cassava	15	526.65	0.11	5.00	......	1.02
Cotton-seed hulls	6.39	....	0.06	1.67	......	0.11
Cotton-seed meal	1.27	....	0.46	0.22	......	0.15
Totals		526.65	0.63	6.89		0.28

Nutritive ratio 1 : 12.

The animal was kept upon this ration twelve days, the last five of which constituted the collection period from which the excrement was all collected and subjected to analysis. * The cassava fed during this period was dug and cut fresh daily and samples were subjected to analysis. The grain constituents of the ration were weighed and thorougly mixed at the beginning of the feeding period and sampled for analysis. The quantities constituting the single feedings were then carefully weighed into Manila sacks, in which they were placed aside, the contents of each sack constituting a single grain feeding to which the ration of cassava was added at the time of feeding. Analysis of the excrement showed the following composition.

COMPOSITION OF THE EXCREMENT.

Dry Matter.	Protein.	Fat.	Fiber.	Ash.	Extract Matter.
27.53	2.96	0.18	12.61	1.43	10.35

This analysis, together with the composition of the ingredients of the ration, furnishes the data for determining the digestibility of the cassava fed.

(*See table on next page.*)

The difference between the digestible nutrients of the other constituents of the ration and the total of the digested constituents is the proportion of each nutrient digested from cassava, which, reduced to percentages as shown in the above table, forms the so-called digestive coefficient, so that the result of this experiment shows

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* The steer had been feed upon a ration of the same ingredients in somewhat varying proportions for two weeks previously, that the proportions which he would consume with least waste might be learned. A comparatively short final period was therefore adopted.

DIGESTIBILITY OF THE RATION.

Amount of Food and Excrement.	Pounds.	Dry Matter, Ozs.	Protein, Ozs.	Fiber, Ozs.	Extract Matter.	Ash.	Fat, Ozs.
Cassava	67.50	379.18	31.96	136.18	111.78	15.44	1.94
Cotton-seed hulls	28.75	419.00	13.34	217.04	152.72	12.34	10.12
Cotton-seed meal	5.62	82.54	38.02	5.03	23.59	6.47	11.59
Total ration		811.08	83.32	358.25	288.09	34.25	23.65
Excrement	1380.5 ozs.	379.91	40.84	164.01	142.83	19.73	2.48
Amount digested		432.17	42.48	194.24	136 26	14.52	20.17
Amt. digested from hulls and meal		234.52	34.78	85.33	74.25	4.49	19.02
Amt. digested from cassava		197.65	7.70	108.91	62.01	10.03	1.15
Per cent. digested from cassava		52.12	24.06	79.87	55.47	64.96	59.28

the digestive coefficients of cassava to be as follows: Protein 24.06, Fiber 79.87, Extract matter 55.47, Ash 64.96, Fat 59.28, Dry matter 52.12.

The digestion coefficients of Irish potatoes, used in the absence of determinations for cassava, are as follows: Protein 44, extract matter 91 and fat 13. The variation thus shown is very considerable, and the necessity for determining the coefficients for each feed-stuff is apparent. The proportioning of the cassava rations if based on the real coefficients would have been materially different from the proportions actually used.

SUMMARY.

1. Florida possesses all the requirements of a natural stock country in an exceptional degree.

2. Economical stock feeding requires the combination of both flesh-forming and fat-forming foods in certain proportions, varying with the class and condition of the animal. The proportions for any requirement, however, are fixed, and must furnish definite amounts of protein and carbonaceous materials.

3. Florida produces numerous and economical feedstuffs of each of these classes in abundance; two of the former, namely, beggar-weed and the velvet-bean, and one of the latter, cassava, are almost distinctively Florida crops. In addition to these we produce the typical forage and feed-stuff crops of the Southern States.

4. The feeding value of any feedstuff depends on the digestibility of the constituents fully as much as upon the mere composition of the article.

5. Experiment has shown that there are definite "feeding standards" for each class of life-stock, and that by means of the composition of the digestible part of differ-

ent foods it is possible to so proportion the ingredients of rations as to meet the actual requirements of any animal.

6. The amount of food which may be economically consumed by any animal varies with the weight of the animal in question, and should be proportioned to the live weight of the individual.

7. The experiments recorded were with average native animals, fed native feedstuffs under natural conditions.

8. The three rations fed to steers gave percentage of gain and the greatest daily average gain in the following order: Cassava, cotton-seed products and corn meal. The percentage of dressed weight shown as the result of slaughtering was in the same order.

9. In the comparison of native steers with grade animals the former made the largest gain, but the latter the largest proportion of hind-quarters, and heaviest net weight.

10. The quality of the beef produced was fully equal to the Western beef offered in our markets.

11. The result of feeding showed a profit on the investment as follows: Cassava 48.82 per cent., cotton-seed products 87-43 per cent., corn-meal 14.69 per cent. The grade steers gave a profit of 26.73 per cent. as compared with 48.82 per cent. from the natives on the same ration.

12. Velvel-bean (pod) meal is believed to be the natural protein food for Florida feeders, and the necessary complement to cassava. It could not be used for experimental rations, however, until its digestion coefficients had been thoroughly established. Its use with cassava would have very materially reduced the cost of the ration and the resulting product.

13. After being placed on full feed 70 days of feeding seems to bring Florida steers to their maximum gain and most profitable point. For animals taken directly from the range about 30 days are required for getting upon full feed.

14. By comparison with the results of actual feeding experiments in Texas and Nebraska, two great cattle feeding States, our Florida steers gave a profit of 23.35 per cent. over the results in the former State, while our average gain per day was double that of the latter and our actual cost per pound of product was less than one-half as much. Our results, moreover, were secured in one-half the time required in Nebraska.

15. The rations tested with hogs showed results in the following order of merit: Cassava ration, corn ration, potato ration, corn alone.

16. The native hogs, gave a higher proportion of dressed meat than the cross-bred animals.

17. The determination of the "digestion coefficients" of each feed-stuff is shown to be necessary to the most economical feeding. The coefficients as actually determined, for cassava are materially different from those used as a substitute.

BULLETIN NO. 56. **MAY, 1901.**

FLORIDA AGRICULTURAL EXPERIMENT STATION

The Cottony Cushion Scale

By H. A. GOSSARD.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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ERRATA.

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"fungus," page 327, should read fungous.
"Coccide," page 338, should read Coccidae.
"those," page 354, should read these.

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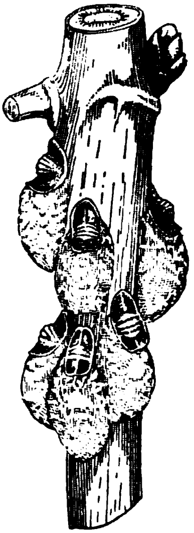
THE COTTONY CUSHION SCALE,

Icerya Purchasi Maskell.

IN AUSTRALIA.

The Cottony Cushion Scale is a native of Australia. In its original home it attracts comparatively little notice, seldom multiplying to such an excessive degree that it threatens important agricultural interests. The names Fluted Scale and Australian Scale are also applied to the insect. In Australia and South Africa it is sometimes alluded to as the Australian Bug.



Pulvinaria innumerabilis **Ratho. (After Miss C. M. King in Bulletin No. 43 Iowa Station, by Wilman Newell.)**

It seems that in the Australian fauna this scale occupies about the same economic position that the Cottony Maple Scale, *Pulvinaria innumerabilis*, an insect belonging to the same family, the Coccidae, holds among the insects of this country. Local outbreaks of either at times may be observed in their respective home countries, but natural checks serve to keep them from inflicting severe damage upon more than restricted areas. In Australia, various species of lady-bugs, flies, and hymenopterous parasites contribute to deplete the numbers of *Icerya*, and in America the lady-bugs, lace-wings, carnivorous caterpillars, and hymenopterous parasites dispose of the *Pulvinaria* in the same obliging way. To further pursue the parallel both *Icerya* and

Pulvinaria excrete a white cottony mass, which covers and protects unusually well a mass of hundreds and sometimes of thousands of eggs. The scales are at least comparable in size and the sets of changes in the two insects are very similar throughout the course of their development. Both are highly polyphagous, or very indiscriminate in the selection of their food plants. An American lady-bird, *Hyperaspis signata*, feeds in its larval stages in the egg-nests of *Pulvinaria* in precisely the same manner that the celebrated Australian lady-bird, *Novius cardinalis*, does in the nests of *Icerya*, though it is perhaps more rare than the *Novius*. Also the methods by which the two insects distribute themselves are very much the same.

There are other insects in Florida even more nearly related to the Fluted Scale than *Pulvinaria*, but we have preferred to compare these two because *Pulvinaria* is more widely distributed and better known to the majority of observers than the nearer relatives of *Icerya*, and because some of the natural enemies of this native species seem to have taken a liking to the imported one.

THE GENUS ICERYA.

This genus includes a number of important insects besides *Icerya purchasi*, the most noteworthy being *Icerya sacchari* (Signoret), native to the islands of Mauritius and Bourbon, and exceedingly destructive to sugar-cane; *Icerya Egyptiacum* (Douglas), to be found at Cairo, Egypt, feeding upon Banyan and figs; *Icerya montserratensis* (Riley and Howard), Montserrat, West Indies, destructive to Cocoa, Palms and Bananas. Other species are *Icerya rosae* (Riley and Howard), described from specimens found at Key West, Fla.; and

Icerya Palmeri (Riley and Howard), collected on grape at Sonora, Mexico.

ICERYA PURCHASI IN OTHER COUNTRIES.

From Australia this pest has been shipped either directly or indirectly into Tasmania, the Sandwich Islands, Mauritius, St. Helena, New Zealand, South Africa, California, Mexico, Portugal, and Florida. It was also observed in green-houses at Cambridge, Massachusetts, several years ago by Dr. Hagen, but it did not establish itself there, and it seems questionable if it would be able to maintain a foothold in a very cold climate.

It has practically repeated the same story in every land where it has been newly introduced, and is always expected to carry certain destruction among many classes of plants, particularly among those of the Citrus family. It has always practically defied the efforts of the fruit-grower to combat it by artificial means. Importations of the Australian lady-bird have always been singularly successful in reducing this scale to unimportant numbers, and it also appears that certain other agencies may play no insignificant part, during some seasons at least, in keeping it in subjection in Florida.

HISTORY IN CALIFORNIA.

It is believed that the *Icerya* was first introduced into California directly from Australia upon *Acacia latifolia* by Mr. George Gordon, of Menlo Park, about 1868 or 1869. At all events the insects seemed to originate on these plants.

They attracted Mr. Gordon's attention two or three years later and the first printed reference to them was published in the proceedings of the California Academy of Science in 1872. Some reports received by this society during this same year indicate a possible spread by this time of several miles from Menlo Park.

By 1886 the pest was in eight different counties of the state, some of them widely separated from each other. The areas of infection seemed to increase even more rapidly during the next three years and many of the Citrus growers of California had already abandoned or were preparing to abandon their business, when the advent of the lady-bird happily restored the confidence of the fruit-growers and the Fluted Scale has not been a very important factor in California orange culture since.

The suggestion that the enemies of the Fluted Scale might be studied with advantage in their native home and be profitably imported into this country was due to Prof. Riley, who urged upon Congress that either an appropriation should be made for this purpose, or that part of the appropriation given to the Division of Entomology should be made available for paying an agent to travel outside of this country. He found it impossible to secure any action on the part of the National Legislature, although his efforts in this direction were supported by the representatives from California and by officials of the California Horticultural Society. The opportunity was finally afforded by the Melbourne Exposition. Upon request of Prof. Riley, supported by other friends of the enterprise, Secretary Blaine arranged that Mr. A. Koebele, an Entomologist in the employ of the Department of Agriculture, should go to the Exposition under the auspices of the State Department, and was given leave to employ his spare time in making the desired investigations. During the summer of 1888 large consignments of parasitic flies, hymenoptera, and predaceous insects were sent by Mr. Koebele to Prof. D. W. Coquillett, another agent of the Department, stationed in California. These were carefully colonized upon infested trees under closed tents, but no striking success was attained until the Australian lady-bird was received, which at once proved its valuable qualities. Something like one hundred and twenty-seven specimens were received and from the progeny of these bugs alone California was completely stocked and practically cleared of the scale in about eighteen months.

The following letter from Mr. A. Chapman, of California, to the United States Department of Agriculture gives some idea of the rapidity with which the lady-bird does its work after it gets a good start: "The Vedalias that you brought to my place about the 20th of last March and which we colonized on four large orange trees that were covered with Fluted Scale have spread in all directions, although, to begin with they followed the directions of the wind most readily. From those four trees they have multiplied so rapidly that in my orchard of three thousand trees it is seldom that we can now find a Fluted Scale. I find a few of them on weeds in spots, but I can also find the beetles there. The trees have put on a new growth and look altogether different; even the black fungus on the old leaves has loosened its hold and begins to fall to the ground. Besides having cleaned my orchard they spread also to the orchard of my cousin and to my father's orchard; the latter was re-enforced by colonies from Mr. J. W. Wolfskill and from Col. J. R. Dobbins. As my father has some ten thousand trees, and most all were more or less infested, the Vedalias had a grand feast ahead of them, and they have done their work most wonderfully. What I have said of my orchard applies to my father's also, and really to all our neighbors'. When the Vedalias first began to multiply we took colonies of fifty or more in the pupa state and placed them in different portions of the orchard, and even had we not done so the Vedalias, unaided, would have reached there in almost the same time.

"On the Chapman place the Vedalias have cleaned the Fluted Scale off of the one hundred and fifty acres of land. They have taken more than an oppressive burden off of the orchard grower's hands, and I for one, very much thank the Division of Entomology for the *Vedalia cardinalis*, the insect that has worked a miracle."

Very soon after the lady-bird had done its work Prof. W. A. Henry, Director of the Wisconsin Agricultural Experiment Station, visited California and writes thus in regard to his observations upon the result of this importation of the Vedalias:

"A word in relation to the grand work of the Department in the introduction of this one predaceous insect.' Without doubt it is the best stroke ever made by the Agricultural Department of Washington. Doubtless other efforts have been productive of greater good, but they were of such character that the people could not clearly see and appreciate the benefits, so that the Department did not receive the credit it deserved. Here is the finest illustration possible of the value of the Department to give people aid in time of distress. And the distress was very great indeed. Of all scale pests the White Scale seems the most difficult to cope with, and had no remedy been found it would probably have destroyed the Citrus industry of the State, for its spreading to every grove would probably be only a matter of time. It was the Department of Agriculture at Washington which introduced the Washington Navel orange into South California, and the Department has now given an effective remedy for the worst scale insect. The people will not soon forget these beneficial acts."

ICERYA PURCHASI IN FLORIDA.

This pest seems to have found its way into Florida through a curious accident. In 1893 Duncan Bros., a firm of nurserymen at Keene, Florida, addressed an inquiry to a California party regarding the merits of the lady-bug and as to the possibilities of its proving useful against some of our common Florida scales. These nurserymen affirm that they did not request that any lady-bugs be sent, but merely inquired about them. However, their correspondent packed up a number of lady-bugs and also enclosed some of the scales for the purpose of supplying food to the lady-bugs on their journey. The Duncans say further that they were not notified that the scales had been enclosed, and having no knowledge of the fact that the lady-birds would feed upon no other material than this scale, were entirely unsuspicious of danger, so after turning the lady-bugs loose they innocently left the box in which they were received in the neighborhood of one of their grape-fruit trees; as a consequence they found this and some of the adjacent trees infested with the scale a few months later. This consignment of lady-bugs was not sent by the California State Board of Horticulture, nor by any officials connected therewith, according to the statements of Mr. Craw, chief inspector of the California State Board, but he writes to Mr. J. A. Duncan (not a member of the Duncan nursery firm) that he has the impression that one of the County Boards of Horticulture in that State sent some lady-bugs to Florida some years ago. However, we have only been able to learn that the scales were sent by some horticultural official in California, and are unable to say definitely with what Board he was connected, though Mr. Craw gives the name of the Board which is believed to have sent them. Dr. Howard, writing from memory of the oral report made by Mr. H. G. Hubbard to the U. S. Department of Agriculture, gives the name of an official belonging to the same Board mentioned by Mr. Craw as the responsible party.

Mr. Duncan's house was consumed by fire a few years since and all the correspondence relating to the matter was destroyed.

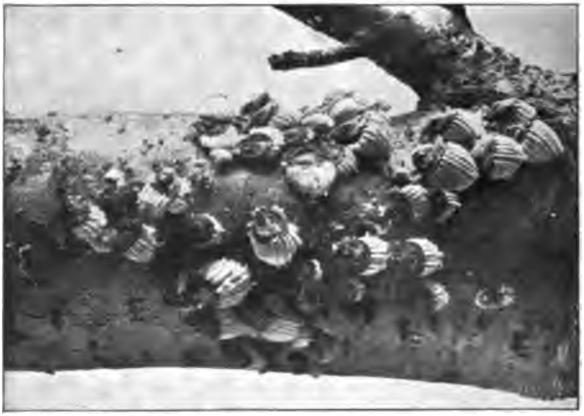
We suppose it is more charitable to say that the California individual who bequeathed this ungracious legacy of his official service to the orange growers of Florida was stupidly thoughtless rather than selfishly thoughtful, or perhaps that the very success of the lady-bird in California had so far removed his fears concerning the scale that he believed it a very immaterial circumstance that it should gain a foothold elsewhere, since it could be controlled, according to his belief, as readily as he had seen it done in his own State; but the best that can be said of the proceeding is that it was inexcusably careless, giving it the most charitable construction possible; for climate or other conditions sometimes render futile in one country, the measures that are strikingly successful in another part of the world, and the expense that attaches to even successful measures is not an agreeable burden when the outlay might have been avoided. Nor would it help matters to plead that the lady-birds were asked for, a supposition the truth of which is denied by the Duncan firm, because were it granted to be true, from any moral standpoint it would still be a criminal abuse of privilege for an official, or any one else acquainted with the nature of this pest, to send it anywhere under such circumstances, even if it were requested and although full warning was sent with it. It would be more agreeable to confine oneself to stating facts without comment, and we would gladly forego writing these words of censure except that we have seen some and have heard of more people in Florida to whom the remarks apply equally well. To be careless regarding the infection of a grove within the natural area of infestation is bad enough, but no patience whatever can be exercised with those who deliberately and knowingly take a first-class risk of infecting districts many miles distant.

When specimens of the scale were sent by the Duncan Bros. to the United States Department of Agriculture for identification, Mr. H. G. Hubbard was sent to Keene to investigate and advise with the owners of the infested grove. The infested trees were cut down and burned and all suspicious stock was treated in the same manner. However, the scale was present in large numbers a few months later and Prof. Rolfs, then of the Florida Station, paid a visit to the locality and repeated the processes of burning and destruction. All ground on which the insect was suspected to be present was covered with straw, chips, and litter, which was then saturated with kerosene and set on fire. Nothing further was heard of the scale in Florida until November, 1898, when Dr. Howard received a letter from Mr. J. A. Duncan informing him that it was in evidence again at Clearwater Harbor, about two miles from the place where it originally appeared. Mr. Hubbard, residing at Crescent City, Fla., received the same information through Mr. D. S. Starr. These letters were referred to the Florida Station and the writer made a visit to the infested districts during the last week of February, 1899.

We learned that a tramp peddler of nursery stock had brought some stuff to Clearwater about two years after the first introduction of the scale in 1893, and had heeled it in in the grove which was found to be most badly infested. This was believed by some to have been the source of a second introduction, though it seems uncertain that he brought any material from California. We are inclined to think from the local surroundings and such evidence as could be found, that there was but a single sending. A second introduction, made in such a way, within two years after the first was thought to have been exterminated, and within two miles of the original site, would be a circumstance even more strange than the original infection.

THE INFESTED AREA AND MEASURES OF SUPPRESSION.

Upon our arrival at Clearwater Mr. J. A. Duncan courteously conducted us over the infested ground so far as it was known to him. We found the insect in small numbers upon rose bushes in about half a dozen yards in the town of Clearwater. We could find signs of its presence in but one orange grove at this time, namely, that of Mrs. Pierce. We found it in greatest numbers upon an undergrowth of myrtles near the railroad track. They were swarming over these bushes in great numbers and in all stages of development. We were unable to find any living scales at all upon Citrus, though the frayed cushiony sacs of dead scales could be seen here and there. We also found adult specimens with filled egg sacs upon two or three different species of Solidago. During this season of the year the myrtle seemed to be the favorite food plant and in May we also found them upon it in great numbers, but in very small numbers later in the season. As this plant is widely scattered over the whole State, especially over those areas upon which cattle pasture, it has proved to be an important factor in the dissemination of the scale. We estimated that about twenty acres of land might be considered infested at this time, though we could find the insect only here and there within this area. We investigated all suspicious territory and made examinations of all suspected orange groves for some five miles out of town, but were unable to find any trace of it except within the corporation limits.



Icerya purchasi; adult females on branch of myrtle,
Myrcia cerifera; from photograph by the author.

When we revisited the place about the 12th of May we found that Mrs. Pierce's orange grove was alive with the insect and that the myrtle trees and bushes were so covered with it that we were able to saw out limbs covered with great white patches of adult scales for photographing purposes. Some of the myrtles showed evidence of weakening and a few afterwards died. The orange grove before mentioned also showed the effects of the intense drain upon it, and at this time we doubted if the trees would survive the season.

Orange tree infested with Cottony-Cushion Scale.
Photograph by the author.

Through the influence of Mr. Jno. Thompson and some of his interested neighbors the Town Council of Clearwater Harbor appropriated the sum of $50.00 to be expended under Mr. Thompson's direction for suppressing and exterminating the insect. Mr. Thompson had cut and burned a large quantity of myrtle bushes before our arrival. When we again investigated this cleared area in July we could find but very few scales where there had been millions of them, and as most of the town cattle ranged freely over this land, we believe the dissemination of the scale during the summer was much reduced by this measure, though of course it would have been too much to hope that it would not eventually replenish its numbers over the same ground. We also found that the scale was known at this time in groves some five miles from town and had also been observed upon myrtle bushes from two to three miles from the section where we first saw it. We judge, therefore, that part of this additional area had been infested the preceding year, but that the numbers of the insect

Nearer view of orange trunk covered with *Iceryas*.
Photograph by the author.

had been so small that we were unable to find it during our winter's visit. Some of the groves, however, were known to have become infested within the five or six preceding months.

While upon this visit we had a meeting with Mr. M. E. Gillette, of Tampa, who had seen something of the scale in California. Mr. Thompson had approached the Board of Commissioners of Hillsboro county for the purpose of securing an appropriation for carrying on the work of suppressing and exterminating the scale and the Board had appointed Mr. Gillette as their adviser and to confer with the Entomologist regarding the most advisable steps to take. As a result of our conference Mr. Gillette recommended that the Board appropriate the sum of $500.00, or so much thereof as necessary, to be expended under the direction of the Entomologist upon warrants signed by Mr. Thompson. Mr. Gillette's recommendation was acted upon favorably by the Board and the amount appropriated.

We visited Clearwater a third time June 29th and remained on the field until August 23d. At this time we found Mrs. Pierce's orange grove very thickly infested, though perhaps not worse than when we saw it in May, and many other groves had been discovered to contain the scale in small numbers. Probably 12 or 15 different groves were known to have one or more trees slightly infested by this date. Some of these groves were located outside the city limits, and three or four of them at a distance of six or seven miles.

We found that the scales had practically left the myrtles by the first of July, very few specimens now being found upon this plant. The trees, on which great patches of them had existed two months before, were almost clean and beginning to put forth a new and vigorous growth. We could find but little indication of the reasons for their departure, but later discoveries enabled us to surmise that they had been swept off by disease. During the latter part of the summer of 1899 the scales steadily decreased in numbers, though the area of infestation was somewhat extended. The numbers began to replenish about the first of the year 1900 and reached a maximum about the first of July. By this date every grove in Clearwater seemed to be infested and the number of infested outlying groves had been, perhaps, more than doubled. The pest commenced to succumb at this date to various enemies, including the Australian lady-bird, and by the end of the year was practically exterminated. A few insects yet remain, but are accompanied by the lady-birds.

THE FOOD PLANTS.

The list of food plants of this insect is very long for the insect is capable of living for a time upon almost anything in the shape of tree, plant, or shrub, but it multiplies most rapidly upon a few favorite plants. The more important plants listed for California are as follows: Pomegranate, Quince, Apple, Peach, Apricot, Fig, Walnut, Locust, Willow, Pepper, Grape, Rose, Castor Bean, Spearmint, Rose-geranium, Purslane, Ambrosia, Polygonum, Nettle, Sweet-gum, Verbena, Veronica, the Acacias, Magnolia, White Oak, Dwarf Flowering Almond, Pecan, Grape, Potato, Nightshade, Amarantus, Chenopodium, and others. We have seen it upon many plants, such as Purslane, Coffee Weed, Bermuda Grass, etc., under the trees, but this sort of infestation must be regarded as accidental rather than normal and the insect in such abnormal situations is itself very susceptible to the attacks of fungus disease. There are but few plants in this list upon which it would thrive to such a degree as to become uncontrollable by ordinary methods if it could gain no access to others. Dr. Riley expressed the opinion in 1886 that besides the Acacias and the Citrus family it would probably be unable to thrive on many other trees than the Quince and Pomegranate in California. We can certainly add Myrtle and possibly Mulberry in Florida. After Citrus, Myrtle, and Mulberry, we have observed it in greatest abundance upon Rose and Solidago. The Pear, the Peach, the Apricot, and the Apple are but little affected by this scale. We have found it difficult to find even a wandering young scale upon a Peach tree standing in an orange grove which was over-run with the insect. The Pine is quite immune from attack, though it is recorded in New Zealand as a food plant, and one or two thickly infested trees are reported to have been observed in Florida. We have personally observed the insect upon Pine, but not in large numbers. We find no record of its having been observed to feed upon Pineapple, but it is not improbable that it would injure this plant, since the mealy-bug, a not distant relative, sometimes infests it in considerable numbers. The Fig, Quince, and Pomegranate are said to be among its favorite food plants.

CHARACTERS AND LIFE HISTORY.

The following descriptions have been abbreviated from the writings of Riley and Howard with a few personal observations added:

THE EGG.—The egg is quite smooth and elongate-ovate in form, and is of a deep orange-yellow color. It is about 0.7 mm. in length. The number of eggs varies according to the condition of the plant upon which the female dwells, the season of the year, and perhaps from other causes also. The greater the number of insects upon a plant the fewer will be the eggs produced by the insect. Mr. Koebele has counted over 1,000 eggs from the sac of a single female, and we have found specimens containing from 600 to 800. The time required for the eggs to hatch after leaving the body of the female varies with the temperature. In the winter season the sacs are usually large and filled with eggs, while in the hottest part of the summer the number varies from one or two dozen to several hundred. Some eggs collected by Mr. Koebele on March 18 did not hatch until May 10, but in midsummer hatching is only a matter of a few days. A female with the Fluted cushion only partially developed, and, therefore, possessing a sac containing eggs, the last of which must have been newly laid, was killed and confined in a glass jar and the young scales were killed as fast as they hatched, our supposition being that the last eggs hatched would very nearly represent the time required in July for incubation after the eggs left the ovary. The last insects were killed about 10 days after the mother-scale was placed in the jar.

THE FEMALE LARVA.—First Stage. The newly hatched female larva is red in color with a somewhat yellowish tinge, inclining towards brown. The outline of the body is ovoid, and is convex above and flat beneath. To the unaided eye it looks like a mite or small spider. The antennae are oblong and six-jointed. The last joint forms a club which broadens out at its tip. The joints are sparsely hairy and the club, in addition to several short hairs, bears near its tip four very long ones which are longer than the whole antennae. The legs are thin and brown in color. The eyes are comparatively large and are each mounted on a short tubercle. At the tip of the rounded abdomen are six small tubercles, three each side of the tip, each of which carries a long stout hair which is as long as the whole body. The body above shows six rows of pores, four along the middle, and one on each side. More or less regular rows of hairs alternate with these pores. In a few days after hatching the exudations from the pores along the back appear as two distinct rows of yellowish or whitish wax, the two rows approaching each other and nearly coalescing before the first moult. The male larva is seemingly identical with the female at this stage of growth, since they have never been separated, though we as well as the agents of the U. S. Department of Agriculture have carefully studied numbers of larvae with this purpose in view.

THE FEMALE LARVA.—Second Stage. It is more rounded and appears less stout than in the first stage. The antennae have the same number of joints, 6, but the relative proportions of the corresponding joints are quite different. As a whole they are relatively much shorter. The eyes do not appear on the margin of the body, and are only seen on a ventral view. The legs are proportionately much shorter. The trochanters are much shorter and consequently form a broader triangle in shape. The six tubercles and the end of the tip are still present, but the hairs which they bear are much shorter. The secretory pores are no longer aranged in rows, but are scattered sparsely over the back and under the sides. The back is more hairy and the short black hairs occur in irregular tufts. The waxy secretion on the back is more abundant, but is no longer in lines,

EXPLANATION TO PLATE.

THE COTTONY CUSHION-SCALE.

Fig. 1.—Outline of the egg—greatly enlarged.

Fig. 2.—Dorsal view of newly-hatched larva—greatly enlarged.

Fig. 3.—A female larva, second stage, ventral view—greatly enlarged; b, antenna of same—still more enlarged.

Fig. 4.—Female larva, third stage, ventral view—greatly enlarged.

Fig. 5.—Adult female, fourth stage, dorsal view—greatly enlarged: a, antenna—still more enlarged.

Fig. 6.—Greatly magnified portion of lateral border of adult, showing base of glassy filaments.

Fig. 7.—Male larva, second stage, ventral view—greatly enlarged

Fig. 8.—Male pupa, ventral view, greatly enlarged.

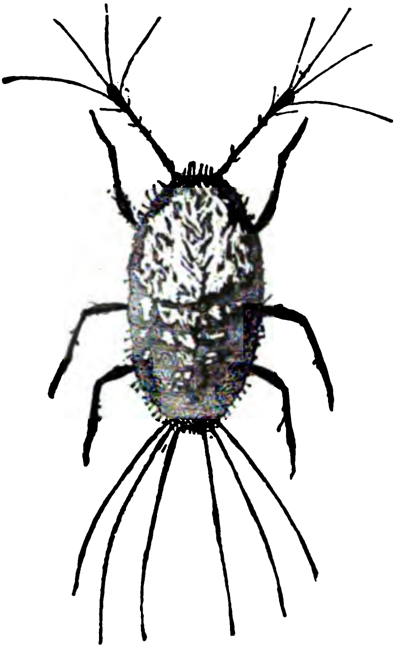


Fig 2.

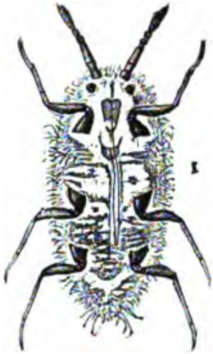


Fig. 7.

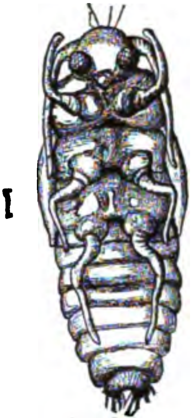


Fig. 8.

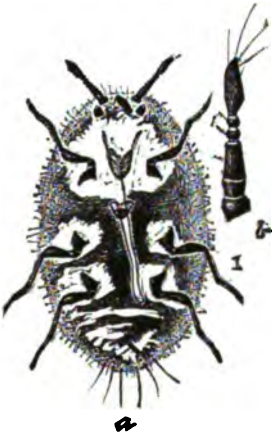


Fig. 3.

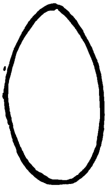


Fig. 1

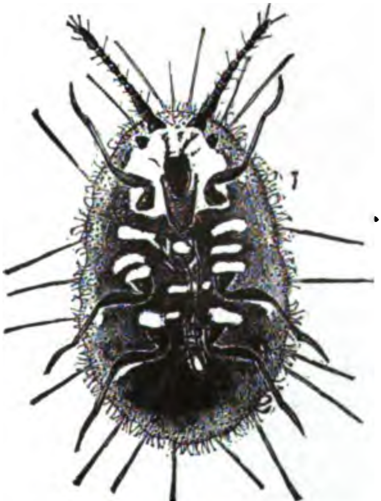


Fig. 4.

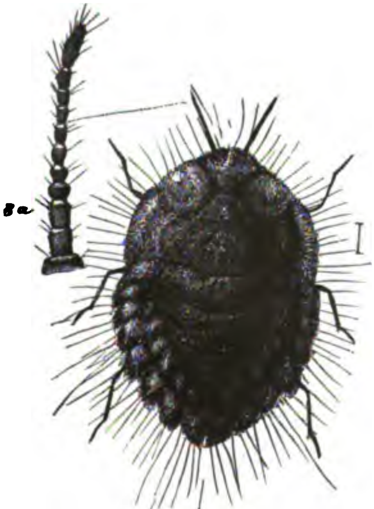


Fig 3

Fig. 5.

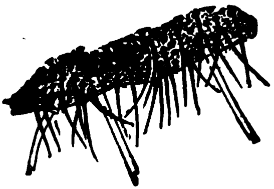


Fig. 6.

Icerya purchasi, (Riley, Division of Entomology, U. S. Dept. of Agr., Ann. Report, 1886.)

conforming instead to the change in the distribution of the pores.

THE FEMALE LARVA.—Third Stage. The body is broadly oval in shape, reddish brown in color, but is obscured more or less by the thick, curly, cottony excretion. The antennae are now 9-jointed instead of 6 and are sub-cylindrical, narrowing somewhat from base to tip. The insect as a whole is much more hairy than in either of the previous stages. The hairs are short and black and grow together in tufts. They are thickly scattered over the thorax, but less so over the abdomen, and may be seen in tufts above the edge of the body. The secretory pores are irregularly scattered all over the back and are more numerous than in the previous stages. They also occur on the lower edges of the body. Around the edge of the body is a row of larger pores, brown in color, each with a circular crown or lip at the tip, from which proceeds a long, fragile, glassy tube. The legs and feet are a little stouter than before. The six anal hairs are still present though hardly noticeable as they protrude from the mass of shorter hairs.

THE ADULT FEMALE.—Fourth Stage. Immediately after the moult by which the insect passes into this stage it is free from the waxy execretion and presents a broadly oval form with two prominent raised surfaces on the second and third thoracic segments. Its color is still reddish brown, with several dark spots along the front sides, and along the sides of the posterior part of the body, while the antennae and legs are black. Just after the insect in any stage has withdrawn from its old shell in moulting the legs are perhaps the most transparent and whitish parts of the body; but they begin to darken in about a half hour and within two hours are black in this stage, and as dark as they become in the preceding stages. The antennae are 11-jointed, the club being one and one-half times as long as joint number 10. The whole body is furnished with tufts of short black hairs which are gathered into a parallel row around the edge of the body. The secretory pores are very numerous, occurring in enormous numbers beneath the sides of the body and scattered more sparsely over the back. The inner row of tufts on the back is broken at its anal point by a depression, in which is situated a very large pore from which the insect occasionally ejects a globule of semiliquid honey-dew. This depression is surrounded by an irregular ring of hairs, which are yellowish in color instead of black. The glassy filaments described in the last stage are now very long and radiate from the body in almost every direction. They break off very easily, yet they often reach a length double that of the insect and her egg-sac together.

THE EGG SAC.—Just as the body of the female begins to swell from the eggs forming inside, the beginning of the egg sac is made. The insect lies flat on the bark. The edges of the body turn slightly upward, and the waxy material of which the sac is composed begins to issue from numberless pores on the under side of the body, but more especially along the sides below. As the secretion advances the body is raised, the head end still being attached, until the insect is apparently standing on its head, nearly at right angles to the surface to which it is attached. The egg-laying commences as soon as the thin layer of secretion has begun on the inner side of the abdomen and it continues during the formation of the sac. Around the edge of the abdomen there soon appears a narrow ring of white felt-like wax, which is divided into a number of flutings. These flutings grow in length and a mass of eggs and wax under them increases, forcing the female upwards until the sac is completed. When complete it is from two to two and one-half times the length of the female's body. It is of a snow-white color. The outside is covered with fifteen of these longitudinal ridgings or flutings of about equal size, except that the middle one is smaller than the others. The upper part of the sac is firm in texture, but the lower is looser and thinner and from the inner side the young make their escape after hatching. The size of the sac and length of time required for its growth depend, leaving the weather and the health of the food plant out of consideration, upon the number of eggs which the female deposits. The excretion of the egg-sac continues as long as oviposition lasts.

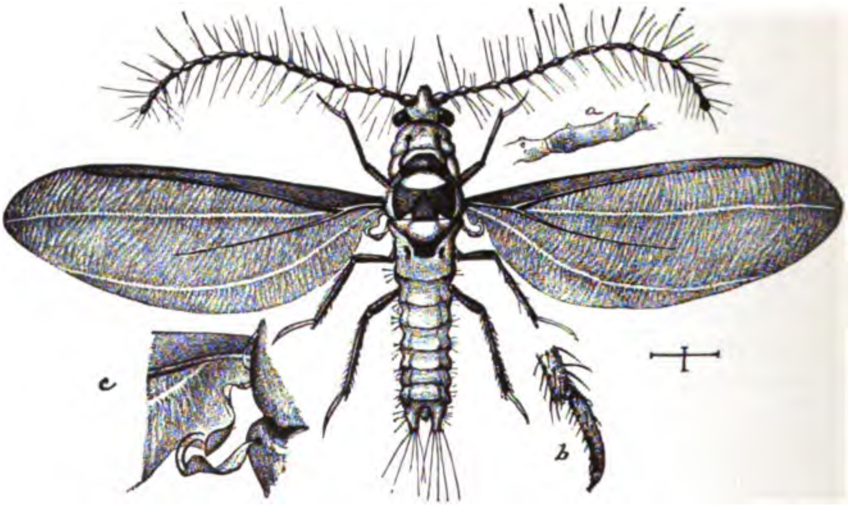
It probably requires from 60 to 90 days to complete the egg-sac from the time of its beginning. The length of time depends largely upon the health of the tree on which the insect is located and also upon the number of insects infesting it. Development is much more rapid upon vigorous than upon sickly trees.

THE MALE LARVA.—Second Stage. This stage of the male larva differs from the corresponding stage of the female in its more slender form, longer and stouter legs, and longer and stouter antennae. The legs and antennae are not only relatively longer and stouter, but are absolutely so. The body is more hairy than that of the corresponding female stage. The antennae are six-jointed and the joints have the same relative proportions as in the female. The secretory pores are not quite so numerous as in the female.

THE MALE LARVA.—Third Stage. In this last larval stage the male is readily recognized from any other stage with the naked eye. Its body is narrower, more elongate, more flattened, and the insect is more active than the female. The general color is also more dull than that of the female. The body is almost naked, being very sparsely covered with short, white, cottony matter, and is destitute of the short black hairs seen on the female during the third and fourth stages. The antennae are 9-jointed. The average length when full grown is about 3 mm. and width about 1 mm.

THE MALE PUPA AND COCOON.—When the male larva is grown and is ready to transform, it seeks a place of concealment, finally secreting itself under a bit of projecting bark, under leaves in the crotch of a tree, or under some mass of females. It often descends to the ground and hides under clods of earth, beneath fallen leaves, or under boards, and in cracks in the ground. When its movements are interfered with by prolonged and violent rain, it pupates wherever it may happen to be upon the trunk or branches of the tree. It exudes a delicate, flossy substance to form the cocoon. This material is waxy in character, but lighter, more flossy, and less adhesive than that of which the egg-sac of the female is composed. When the cocoon has reached the proper length the larva casts its skin which remains in the posterior end of the cavity, and pushes itself forward into the middle of the cocoon. The pupa is of the same general color as the larva and also of the same general form and size. The pupa stage apparently lasts about three weeks.

THE ADULT MALE.—The adult male is a winged insect with dark red body, grayish wings, and of very slender, fragile structure. The antennae are dark colored and have two whorls of light hairs extending from each joint, except joint 1. When the insect is at rest the wings lie flat upon the back. It is readily found in situations where the male larvae have pupated, under boards, beneath cracks, and in the general litter of the grove.



Icerya purchasi (Riley. Div. of Ent., U. S. Dept. of Agr.. Ann. Report. 1886.) a, adult male—enlarged; b, hind tarsus of same; c, wing and poiser of same, showing hooks and pocket—still more enlarged.

THE NUMBER OF BROODS.

There are supposed to be about three generations per year in California, and the length of life of any particular individual, commencing with the egg, probably extends anywhere from three or four to six months. Mr. Koebele observed some individuals hatched from eggs on the 4th of March that cast their last moult on the 23d of May. This would make about 94 days, allowing 10 days for the eggs to hatch; this added to an estimate of 60 to 90 days for the formation and completion of the egg-sac would give a life time of about six months; but under some circumstances we are confident that they mature in much shorter time, possibly in 4 months.

HABITS.

The larvae, in the first and second stages, settle upon the leaves and twigs, generally arranging themselves in rows beside the mid-ribs and along the veins of the leaves. In the third stage they prefer to settle upon the smaller twigs, though some remain upon the leaves and a few travel to the larger branches and trunk. The adults always prefer the trunk and larger branches, though they sometimes develop upon the leaves. They are very rarely found upon the fruit. In any stage the scale is quite active, and during all the larval stages or throughout the greater part of its life it travels freely, but can move in a very limited way after reaching the adult stage. The tendency of the insects is to crawl upwards, and when they are washed from the trees in large numbers by rain, or are shaken off by the wind, they will collect in great numbers upon the top of barrels, posts, or any standing object beneath the trees, and some of them at least will starve to death rather than descend. Both sexes, in their larval stages, are most active during the hotter parts of the day, and remain stationary at night, but the winged male is rather sluggish during the day, becoming active during the latter part of the afternoon just before dusk, at which time copulation occurs.

One of the most characteristic accompaniments of the scale is the black or smutty appearance of the leaves and trunks of the trees which they infest. This appearance is due to the growth of a black mold, *Meliola*, in the honey-dew which is excreted by the females in large quantities. Plant-lice and other Coccide also excrete honey-dew in large quantities, so the appearance is a very common one where any of these insects occur. Sometimes the excretion is so plentiful that it falls in drops, reminding one of a sprinkle of rain, and again, especially in the early morning, the drops are sometimes suspended by slender glassy threads of syrup, reminding one of glass bulbs blown on the end of fine capillary stems.

METHODS OF DISSEMINATION.

The modes of spread are various and depend upon a number of different agencies. The insects, when very numerous, cling with a light hold to the branches of the trees so that many of them probably let go, and they are so light of body that they may be carried a considerable distance by the wind. The wind is also apt to carry them upon the webs of gossamer spiders which are often present upon the same trees with the *Icerya*. They are also transported upon the feet of birds, lady-birds, the feet of predaceous or honey-loving insects, in the hair of animals, and upon the clothes of men. Perhaps the most important mode of dissemination is by the shipment of nursery stock. Mr. Koebele gives the following interesting observation regarding the agency of the wind: "In the infested part of Los Angeles is a large vineyard, on both the north and south sides of it is an orange orchard infested by these insects, but while the recently hatched insects occur on vines as far out as the 10th row of grape-vines, on the south side of the vineyard, they are not found upon the vines beyond the third row on the north side, the wind as stated above blowing from the southwest. No adult females are to be found on any part of this vineyard, and the young insects must have been carried by the wind from the infested orange trees on either side of the vineyard.

Although other agencies may perhaps have had as much or more to do with the distribution of the *Icerya* in Hillsboro county, the general effect of the wind may be observed from the fact that the insect is scattered more generally to the eastward than in any other direction, except in a few cases to the northward and southward, where domestic animals are known to have been the source of infection. Mr. Hollis believes that his grove, situated about one mile from the centre of the infection, became infested through the agency of birds. He observed that the worst infested tree contained a nest, and that the branches near the nest were infested worse than any other part of the tree. Mr. W. McMullen, living in the neighborhood of Largo, about six miles south of Clearwater, purchased some cattle about Christmas time, 1898, that had been wandering over the infested prairie near Clearwater Harbor and turned them into his grove, wishing to fertilize the land in this way. This prairie was not known to be infested at the time of the purchase. In April following he found a few of his trees infested by the scale in small numbers.

Another grove is believed to have become infested through the agency of a couple of vagabond dogs that were in the habit of wandering among the bushes and myrtles about Clearwater, and which came to the grove and amused themselves by digging out a Florida "salamander." Sometime afterwards some trees near the place where the dogs had been digging were observed to be infested.

It must be remembered that the myrtle, *Myrica cerif-*

era, is one of the favorite food-plants of the *Icerya* and that it is widely scattered over the entire State, especially over those areas upon which cattle pasture and, therefore, must be a most important factor in scattering the insect in Florida.

NATURAL ENEMIES.

We have already noticed that the *Icerya* is kept in effectual check in Australia by *Novius cardinalis* and other enemies. This lady-bird, as we have seen, became famous for the work that it did in California. It has been equally successful in every land into which it has been introduced. Mr. R. Allan Wight, of Auckland and New Zealand, gives the following account of its work in the columns of the Garden and Field, published at Adelaide, South Australia: "It may interest some of your readers to hear news of your native lady-bird, *Vedalia cardinalis*, which has done such good service of late years, both in New Zealand and California, against *Icerya purchasi*. It will be remembered that the beetle, although native to Australia, has never been any other than an inconspicuous and rare insect in its own country, and that it was in New Zealand that it first shone out in all the glory of a conqueror of one of the greatest of known pests. Some two years ago everything seemed white around Auckland with the clustering *Icerya*, a great many orange and lemon trees (including one entire lemon orchard) were dead, and the prospect was as gloomy as could be, till *Vedalia* (which had been accidentally imported from Australia) appeared on the scene. Astonishing as it may seem to be, and incredible, within one year hardly any of the scales were left, and the lady-birds had also disappeared. The little beetles are rank cannibals when pressed by hunger, and as no one was able to discover any other food but *Icerya* upon which they will feed, it was feared that, in the absence of *Icerya*, they would become extinct. Therefore considerable uneasiness was felt when, some time ago, the scale again began to increase rapidly, and spread everywhere, and, as yet, no *Vedalia* were to be seen.

"On the 8th of April last I arrived in Auckland to see whether it would not be possible to procure a few, when I found that in the meantime they had again appeared and cleared off the accumulated *Icerya* with an incredible celerity, and then vanished for a second time. Even in a distance of 30 miles from the city, where only at the end of last December I had seen many thousands of *Icerya* females, with full ovisacs and larvae without number, only nine ovisacs of eggs and about 50 scales could be obtained wherewith to feed any *Vedalia* that might be procured on a voyage. On all the Acacia hedges around Auckland in every direction for miles and miles where formerly buckets full of ovisacs could have been gathered in a few chains there was not a scrap of even a torn one to be seen, and in all the nurseries, whose owners had formerly been in despair, not one single specimen of either insect was to be procured. Only after many days of fruitless search an Acacia hedge was come upon where 79 *Vedalia* were procured and sent to Nelson, an intended shipment to the Cape of Good Hope having been abandoned. From observation, which it is needless to particularize, the following conclusions were arrived at: (1) The *Vedalia* has unquestionably some other food resources besides *Icerya* and its cannibal practices, although it could not be determined at the time; (2) that in its first attack upon *Icerya* it runs over the enemy and leaves a few eggs (two or three) in some 5 or 6 per cent. of the ovisacs, and it is these and the few larvae which escape that found the second *Icerya* invasion; (3) that the beetles keep on the hedges all through the winter months, although so hidden as not to be easily captured, without a net; (4) that the *Vedalia* larvae soon perish for want of food, but in the imago state they will live for a very long time, probably nearly throughout their natural life, feeding upon their own eggs, which they devour as soon as laid; (5) that this exhausting system of warfare will very soon cause both insects to become exceedingly rare, but that *Icerya* will always have a great advantage in its food being abundant and always at hand, whereas that of *Vedalia* is at best uncertain and doubtful."

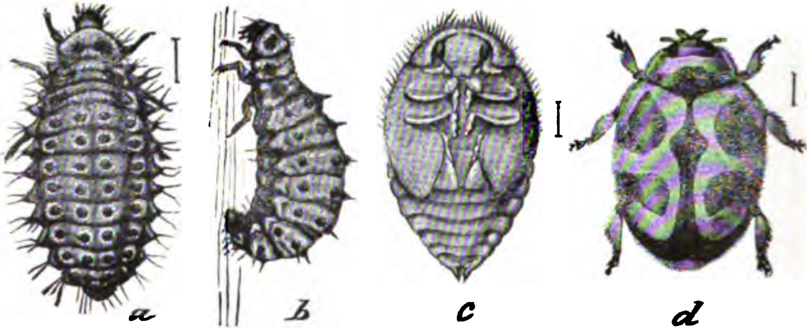
From the Report for the year 1896, by Mr. C. P. Lounsbury, Government Entomologist of the Cape of Good Hope, we quote as follows: "The insect (*Icerya*) was reported in South Africa by Roland Trimen in 1877; it has been known by him since 1873, and was first observed in the Botanical Gardens at Cape Town. Gradually it extended its range through all parts of the colony and neighboring states, everywhere proving destructive, especially to all kinds of Citrus trees. As in other countries, all sorts of remedial measures were adopted, but none proved of much value. The cultivation of Citrus fruits and some of the other favorite food plants of the insect was rapidly becoming impossible in the country, when natural checks appeared and stayed the invasion in a manner unparalleled in the annals of Entomology. These natural checks, which are predaceous lady-birds, are now prevalent in every locality frequented by the scale and suffice to keep it reduced to small numbers. There still remain many isolated farms in different parts of the colony not yet reached by the scale, and, consequently, neither by the enemies of the scale. These places have most to fear from an outbreak."

The predaceous lady-birds referred to by Mr. Lounsbury, are the *Vedalia*, which were obtained and introduced from California, and another lady-bird known as *Rodolia iceryae*, probably a native of South Africa, and which also seems to have quite a liking for the scale. We further quote from Mr. Lounsbury's Report: "Upon isolated farms, and perhaps even in small towns where there is little for the scale to infest, it may occasionally happen that both the scale and its lady-bird enemy become extinct, the former from the attack of the latter, which in turn dies for want of food. In such a case the scale may spread and cause much damage if again introduced, but, fortunately, the lady-bird seldom exterminates the scale, simply keeping it reduced to uninjurious numbers. These numbers, of course, are subject to considerable variation. Sometimes a plant or two become considerably infested before the lady-bird puts in its appearance, but given a little time it will almost invariably come. Therefore, the appearance of the scale on a few plants is no cause for anxiety, except on isolated farms, or in small towns where it has hitherto never been known, or has been entirely absent for a long period. The *Vedalia* is not known to attack any other scale insect than the Australian bug in South Africa; and it is undoubtedly this lady-bird, not the *Rodolia*, that now holds the scale in check in most parts of the colony.

"When the Australian bug anywhere in this colony increases to an alarming degree a few specimens of either *Vedalia* or *Rodolia* should be procured and liberated on one of the infested trees. The procurement of the lady-birds may be attended with some difficulty. As has been explained they are constantly present about the large towns, but so well do they keep their prey in subjection, that they are never long to be found at any one place, and several hours or even days may be spent in searching for them before the requisite number is obtained."

THE LADY-BUG IN FLORIDA.

One lot of lady-bug larvae was sent us by Mr. Craw, of the California State Board of Horticulture, in February, 1899, but were delayed on the road by snowstorms, reaching Lake City on the date of our last big freeze, February 13th. They were all dead upon arrival. Other consignments of both adults and larvae were sent directly to Clearwater in May and June. Adults were invariably dead upon arrival, and their eggs in the shipping-cases were too dry to hatch. Larvae and pupae came through in good condition and from them somewhere between two dozen and thirty adult bugs were hatched, kept under close observation until they were observed to have copulated, after which they were confined for a short time in a large sack upon thickly



Novius cardinalis (Riley and Howard, Div. of Ent., U. S. Dept. of Agr. Insect Life, August, 1891.) a. Larva, dorsal view; b. larva, from side; c. pupa; d. adult—enlarged.

infested limbs, so as to insure the deposition of their eggs before they flew to other trees. As we were not expecting a sudden onslaught from a fungus disease, we naturally put our lady-bugs upon the worst infested trees to be found in the worst infested grove. It was but two or three weeks from the time the lady-bugs were liberated until a fungus struck the scales, and we suppose that the lady-bug larvae must have perished from want of scales to feed upon, unless they, like the scales, withered before Florida rain and heat. We hoped that some of the bugs had gone to other trees than the ones upon which they were turned loose, since they were confined in the sack not more than 12 or 15 hours, or over night, and that many lady-bugs would appear in the grove later, but nothing was ever known to develop. The trees upon which the bugs were liberated were almost wholly free from scales in April, but later supported them in numbers. We attribute the temporary disappearance of the scales, however, to fungus disease and native predaceous insects, and not to a probability that any lady-bugs had anything to do with it. We instructed our correspondents to keep a careful watch on the field and report to us later in the season if circumstances seemed to favor a new introduction.

In December letters from two Clearwater correspondents indicated that the scales were sufficiently numerous in some groves to warrant the belief that the introduction of the lady-bug would prove successful. We therefore wrote to the California Board on the 2d of January, informing them of the situation and our desires, but learned that their colonies were low and they could not supply us with bugs until the latter part of May. However, Mr. Kimball, a gentleman stopping in Clearwater, succeeded, through the request of the Fruit

World, in getting a consignment from one of the County Boards of Horticulture, at San Diego, California, about the middle of April, and the bugs were turned loose upon an infested tree in accordance with instructions received along with the insects. While no obvious explanation for their failure to propagate can be given, no subsequent trace of them could ever be found. It is possible that they were not wasted, but that their progeny became mixed with that of later importations of bugs, colonized at no great distance from them, though we have no evidence to suggest such a probability.

Three colonies of insects were sent to Clearwater by Mr. Craw, under date of May 28; one of them was sent to Mr. Thompson, at our request, the two others being sent to Mr. H. C. Markley by request of his brother, a resident of California. We instructed Mr. Thomson to have an infested tree tented with cheese cloth for the reception of the insects upon their arrival, as previous experience in putting bugs upon open trees had failed to give satisfactory results. Mr. Markley, after conference with Mr. Thomson, adopted the same plan, using canvas instead of cheese cloth. One of his colonies was placed upon a tree standing in his yard in Clearwater, and the other by Mr. Thomson's advice was sent to the grove of Mr. Wm. McMullen, about seven miles from town. The rainy season setting in at about this time, and fearing another onslaught of fungus, we wrote Mr. Thomson about ten days after he received the lady-bugs to remove the tent and give them the freedom of the grove. This suggestion was at once put into practice by Mr. J. H. Brown, who had been placed in immediate charge of the insects, and who advised Mr. Markley to pursue a similar course. The heavy covering upon the colony at Mr. McMullen's grove was not removed so soon, and, as a consequence, the insects did not do nearly so well. We made an examination about one month after the insects were loosed and found larvae well scattered over perhaps twenty different trees, adjacent to the one upon which they were liberated, and, while they were not so widely scattered at Mr. Markley's place, they were much more readily found in numbers.

Since some caution must be exercised in choosing trees upon which to plant colonies, if embarrassment from fungus was to be wholly avoided, we spent a day with Mr. Brown in going over the infested territory and arranged to have him take charge of the work of distributing bugs over all the infested district as soon as sufficient material could be procured.

During August and September the bugs got under such headway that to use the language of Mr. Brown, "It was as if a fire had gone through the scales," the whole country being practically cleaned up by October 1. An inspection made about the last of January, 1901, discovered only a few scales in a single grove in Clearwater. Mr. Brown reported that both scales and lady-bugs were present in a grove about six miles from town, but he knew of their being present nowhere else. Letters dated since April 1 report that lady-bug larvae are present in both groves referred to, from which it seems that the South African experience is to be repeated in Florida, and that we can depend upon the lady-bug remaining with us as a fixture. We doubt if it would be practicable to maintain an artificial propagating establishment for lady-bugs with our present resources and conditions. The area of infestation appears to us to have become sufficiently large to warrant the belief that the lady-bug will remain permanently upon the field despite the slender food supply available in autumn, and that the chances for its permanent retention have been greatly increased by the failure to get it successfully established in 1899. Some means should be provided by Hillsboro county or by the State, by which a record can be kept of where it shall have been last seen, and colonies can, therefore, be secured for infested spots from which it is absent. Under ordinary circumstances much less than $100 per annum will be sufficient for this purpose. Localities, likely to become infested, are apt to be at some distance from Clearwater rather than in its vicinity.

LIFE-HISTORY AND HABITS OF THE LADY-BIRD.—Each female lays from 150 to upwards of 200 orange-red eggs, depositing from one to three or more beneath the *Icerya* or on the side of the cottony egg-nests. The eggs hatch in less than a week, usually in 5 or 6 days, when the young larvae burrow into the egg-masses from below and consume the eggs; later they attack all stages of the *Icerya*, the adults agreeing with the larvae in habit. The larva completes its growth in about 3 weeks, when it attaches itself, head downward, to bark or leaf, and pupates. In two or three days the skin splits open along the back exposing the pupa to view. The pupa stage lasts about a week when the adult beetle emerges with general reddish color and black markings. Two black crescents with convex sides turned toward each other are conspicuous on each wing cover. Egg-laying begins in a day or two after the adults emerge. The insects are known to feed only upon the *Icerya* and their own kind. The females often devour their own eggs and the stronger larvae the weaker ones when food is scarce. The adults live for several weeks.

NATIVE ENEMIES OF THE SCALE.—At the beginning of our investigations, July, 1899, we were able to find some trees thickly infested with scales, which were being rapidly consumed by a small caterpillar which we were soon able to identify as *Loctilia coccidivora*, an insect hitherto recorded as feeding upon the *Lecanium* scales, *Pulvinaria*, mealy bug, the wax scales, the cochineal insect, and at times upon the armored scales. Mr. H. G. Hubbard, in speaking of this insect, writes as follows:

"Underneath the covering of web the caterpillars of Dakruma (*Loetilia*) move back and forth actively engaged in removing the bark-lice from the bark and suspending them in the investing web. Nothing could be more thorough than their work. Branches incrusted with *Lecanium* scales are very quickly cleared of the lice, and the Dakruma larvae do not cease to extend their operations until every individual coccid in the colony has been lifted from its place and securely fastened in the web above.

"While constructing their galleries the caterpillars stop occasionally to feed upon the coccids. At such times they seldom finish their repast, but, like busy workmen as they are, hastily snatch a bite or two by way of lunch, and suspend the half-devoured fragments in their web. When the entire scale colony has been secured within its net the Dakruma larva rests from its labors and feeds at leisure upon the coccids suspended in the larder. It devours not only the eggs and the young and the softer parts of the bark lice, but even to some extent the harder skin or scale. The result of its operations upon *Lecanium* and *Ceroplastes* scales is to utterly annihilate the colonies of these insects which they attack."

What Mr. Hubbard observes of this insect in connection with the *Lecaniums* and *Ceroplastes* we also affirm of it in regard to the Cottony Cushion Scale. We were curious for a long time to learn if the *Loetilia* would be able to catch up with the scale in the course of a season, since the young scales fasten upon the leaves of the trees and only upon reaching maturity go to the trunk and limbs where the caterpillars make their webs. We, therefore, had these trees upon which the caterpillars were in greatest numbers carefully inspected at intervals, and under date of September 22 our correspondent, Mr. Duncan, wrote that these trees, which had attracted our special interest, were "pretty well rid of the old bugs, but there were a good many young ones on the leaves."

An inspection of these trees made by the writer, April, 1900, disclosed a scale here and there, but they were practically free. The trees were not greatly injured, and although white with *Icerya* last summer, they appeared at this date to have suffered more and to be in greater danger of injury from the long scale, *Mytilaspis gloverii*, than from *Icerya purchasi.* Observations upon the same trees in July, 1900, showed considerable *Icerya* upon them, and the caterpillars just beginning to put in their appearance. One of the trees became infested just badly enough to attract notice in 1899, but it seemed impossible for any of the scales upon it to reach maturity before they were attacked, and only a few larvae could then be found upon the leaves. At the time of the last examination referred to, this tree was thickly infested, while its near neighbor, which was coated with the pest the preceding summer, was in much better shape and not suffering a great deal, though still threatened. In 1899, we found the same caterpillar scattered everywhere over the infested district and multiplying rapidly. Among the myrtles and even in places where would be found an isolated infested tree, half a mile or more away from others, we found this little caterpillar at work, and often in numbers. We do not recall an instance of finding an infested locality, whether containing one or many trees, where, by diligent search, we did not find the *Loetilia* also. In the forks of the trees just now discussed, where the scales had gathered in great white patches, covering in total several square feet in area upon a single tree, it was almost impossible to find an adult that had not been eaten out and the egg-mass completely destroyed. The caterpillar seemed to be not present with the first brood of scales, which apparently hatched in January or February, nor with the second brood, which in very general terms may be said to appear about the first of May, but the moths must issue some time during June, for the caterpillars are to be found during the first week in July and are abundant by August. We, therefore, consider it probable that these insects feed only upon the third and subsequent straggling broods of scales that appear in the fall. The broods of *Icerya* so overlap each other and appear so irregularly that their separation is not very readily made.

We found a number of other predaceous insects, harvest mites, forficulas, lace wings, etc., feeding upon this scale, some of them possessing a considerable degree of efficiency. The work of none of these insects can be considered equal to that of the Australian lady-bug, for the reason that their modes of attack are different, and the caterpillars, which alone agree in habit with the lady-bugs in eating the nests, will not go out upon the leaves hunting for their dinners. However, it must be said in their favor that they are natives of Florida, that they feed upon other insects than the Cottony Cushion Scale, and that they will never be absent, nor become lost, nor need artificial propagation in order to secure their perpetuity.

Fungous Disease.—During the season of 1899 a fungous disease which, as yet, had received no biological study, but determined by Mr. Ernest Bessey to belong in the family *Phymatasporae*, destroyed more scales than any other agency. The first diseased specimens were found on the 12th of July upon certain badly infested orange trees, and a few days later we noticed that the weeds and undergrowth of this, the worst infested grove in Florida, especially in damp situations, were covered with the remains of slaughtered scales. We, therefore, impatiently awaited a shower of rain, and from the 23d to the 26th of July were favored with a continuous downpour, accompanied with heat, as much as 14 or 16 inches of water, at the very least, coming down in 72 hours. We examined the trees upon which the fungous was discovered, at the conclusion of the storm, while it was still raining, and found them enveloped in a white winding sheet of dead scales from the trunks to the tips of the leaves. We estimated that not less than ninety-five per cent. of the scales in all stages had perished. About a month later we estimated that not more than one scale in a thousand was living upon what had been the worst infested trees in the grove, and the few living ones that could be found were newly hatched larvae, a few of the eggs in the egg-sacs apparently not having been completely destroyed by the fungus. During the month following the heavy rain mentioned we had but one or two light showers, so the conditions for the rapid growth and spread of the fungus were not so favorable as they might have been. Notwithstanding the drought at the time of our departure from Clearwater on the 23d of August there was hardly an infested tree upon which the fungus was not established, and trees that gave no evidence of it two weeks before now had many diseased specimens. It seems certain that the air was at this time full of the floating spores of the disease, and that in our naturally moist atmosphere, with the help of the dews, the disease is enabled to gradually progress, even when comparatively dry. After the disease is established upon a few specimens located in different quarters of a tree a driving rain will drench the remainder with spores, and in a short time afterwards the tree is largely cleared of the scale. The egg-sac, when wholly or partially formed, furnishes sufficient protection to the eggs and newly hatched insects beneath to render improbable the complete annihilation of the bugs for several weeks, but trees inhabited by scales in the various larval stages are practically freed of them in a few days.

Mr. Duncan, writing under date of September 22, reported that the bugs in the grove before mentioned were decreasing; that the fungus was affecting them very badly; he could scarcely find one that was not affected, and that while some trees in the grove still harbored young scales, the fungus was to be found upon all. He further reported that about 95 per cent. of the insects in some other groves that were just beginning to show the presence of the fungus at the time of our departure were dead, and the owners stated that where ten scales existed three weeks earlier not more than one could be found at the date of writing. The fungus was found present in a number of groves in the latter part of April, 1900, and by the 15th of July following the scales in the myrtle thickets were nearly all dead through its agency, and from 25 to 75 per cent. of those in infested groves were dead, with the disease rapidly spreading and daily increasing in virility. That this disease and the native insects mentioned, possess capabilities of immense value for subduing the insect during some, and perhaps we may say all seasons, we do not doubt, but it should still be remembered that without the lady-bug present the scale multiplies vigorously during certain periods of the year and that it is capable of inflicting great damage during this time. The third brood of scales is well on the way to maturity before any of those native destroying agencies appear.

SPRAYS AND WASHES.

The experience of several growers at Clearwater has shown that the scale may be almost exterminated by the free and persistent use of resin-wash or kerosene applications. When the *Novius* is slow about putting in its appearance two or three applications about a month apart will do much to reduce injury. Not more than three treatments per season should be given if it can be avoided, and more than one or at most two per year are apt to weaken the trees if continued through a series of years. The standard kerosene emulsion may be used, or 15 per cent. of kerosene in mechanical mixture with water may be applied with a Gould or Deming pump. Such applications should not be given during the blooming period, nor until the fruit is a quarter grown, unless the destruction of the scales is a greater consideration than the saving of the crop.

FUMIGATION.

Fumigation of infested trees with hydrocyanic acid gas is the most efficient of artificial remedies, and is accomplished with little danger to the tree. It is but little used on account of its comparative cost. It destroys lady-bugs as well as scales.

ACKNOWLEDGEMENTS.

In conducting this investigation we are indebted to Dr. W. F. Yocum, Director of the Experiment Station, for a generous allotment of time in which to do the work, and all other favors possible; to the Hillsboro Board of County Commissioners for financial aid; to Mr. Alexander Craw, of the California State Board of Horticulture, and Dr. L. O. Howard, of the United States Department of Agriculture; to the Plant System of Railways for transportation; to Messrs. John Thomson, M. E. Gillett, H. C. Markley, and many others for co-operation and favors of various kinds; and to Messrs. J. A. Duncan and J. H. Brown, who have acted as local inspectors in the employ of the County Board, and have kept us accurately informed as to the history of the scale and its enemies. The reports and investigations of the last two gentlemen have furnished the basis for some very important conclusions set forth in this bulletin, and visits to the field have always confirmed the correctness of their observations.

SUMMARY OF IMPORTANT CONCLUSIONS.

1. *Icerya purchasi* is in Florida to stay. It is not known to exist elsewhere than within a radius of seven or eight miles of Clearwater.
2. If uncontrolled, it would imperil and perhaps destroy the Citrus industry of the State in a very few years.
3. It is scattered by wind, birds, animals, men and nursery stock.
4. Its most successful enemy is the Australian lady-bug, *Novius cardinalis.*

5. *Novius* is established in Florida and will in all likelihood remain with us permanently.

6. The scale is in perfect control at the present time.

7. Dangerous outbreaks of the scale are apt to occur outside of the infested district rather than in it.

8. The scale will at times become somewhat threatening, but will be found by the lady-bug if only a few months' time be given.

9. A local inspector in the infested district can be profitably employed by County or State to keep himself informed as to the development of both scale and lady-bug and to collect and distribute the latter when necessary.

10. Native enemies and diseases of the scale are great helps in suppressing it, but cannot be relied upon alone. They confine their work mostly to the third brood of scales.

11. While waiting temporarily for lady-bugs an application of resin-wash, kerosene emulsion, or mechanical mixture of kerosene and water is useful.

BULLETIN NO. 57. JUNE, 1901.

FLORIDA
AGRICULTURAL EXPERIMENT STATION.

TOP-WORKING PECANS.

By H. HAROLD HUME.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

HILL PRINTING CO.,
GAINESVILLE, FLA.,
1901.

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TOP-WORKING PECANS.

Interest in the pecan industry is steadily increasing, not only in our own State, but in others of the Southern States as well. Since the publication last year of Bulletin No. 54, Pecan Culture, A Preliminary Report, the author has visited many pecan groves of the State during the fruiting season, and has been forcibly struck by the fact that very large numbers of small, inferior nuts are produced. This is not as it should be, and the fact that such is the case is but proof of the folly of planting nuts or seedling trees. These are seedling groves and doubtless they are the outgrowth of the very best selected nuts. True, a considerable proportion of seedling trees produce good, sizable nuts, but scores produce inferior nuts, but little larger than chinquapins, and it is a fact which cannot be gainsaid that the seedling pecan, up to the time of fruiting, is an unknown quantity, after which it is too often a disappointment. It is not necessary to say that such trees are unprofitable, and the question naturally arises, what is to be done with them? Only two answers can be given; one is, cut them down and plant budded or grafted trees of desirable varieties. The other is, top-work them. It is needless to say choose the latter, but do not work over all the trees in the grove simply because they are seedlings. Those which produce a goodly quantity of marketable nuts should by all means be allowed to remain; top-work the remainder.

Realizing the importance of the question asked and answered above, considerable attention has been given to the matter. The fact that top-working of pecan trees can be successfully done has been placed beyond the shadow of a doubt, as evidenced in the grove of Dr. J. B. Curtis, of Orange Heights. Photographs are shown of some of the top-worked trees or portions of them, and much valuable information has been secured from the work done there. Pecan trees have been successfully top-worked in Louisiana and others of the Gulf States, but it is extremely doubtful whether the work can be successfully done at any great distance North. This is due to the climatic conditions.

METHODS.

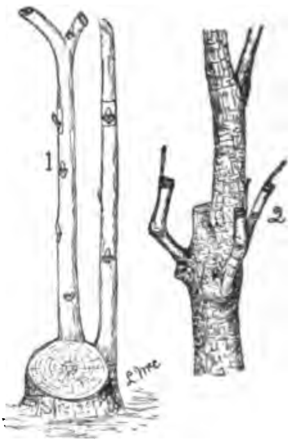


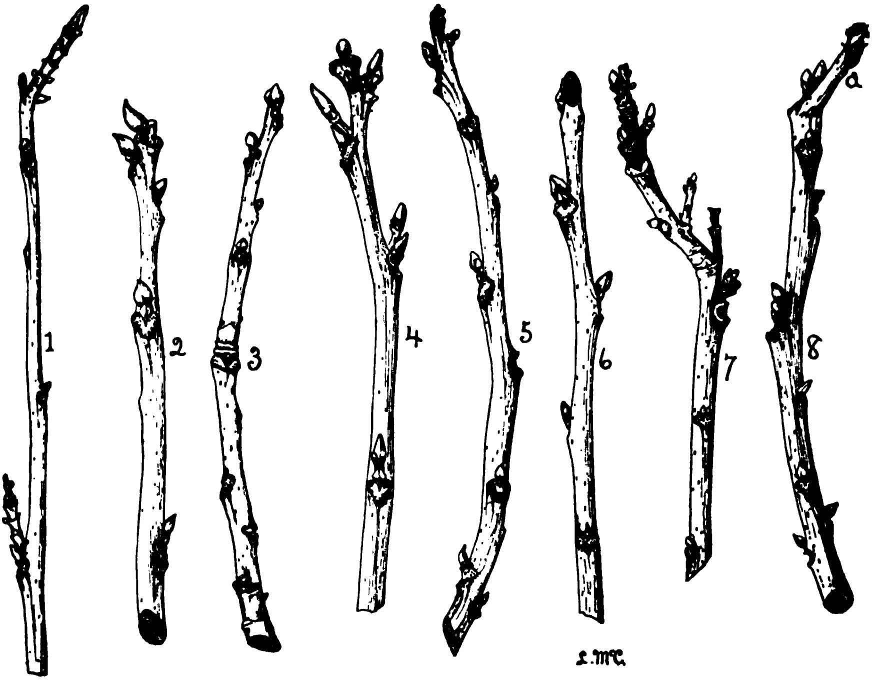
FIG. 1. Methods of budding and grafting.
1. Dormant buds inserted in sprouts.
2. Branches cut back and cleft grafted.

Trees may be top-worked at any age, but the same line of procedure should not be adopted in all cases. Figure 1 shows the sprouts from an old stump in which dormant buds have been inserted.

Plate No. III is from a photograph of a ten year old seedling trunk, bearing a three year old Van Deman top.

Plate No. II, Figure 3 is that of an old tree, top-worked by cutting back and grafting the branches. It is best to insert both buds and grafts in parts having smooth bark, though grafts can be placed in rough-barked parts as well. Frequently trees are in a very undesirable condition for top-working, and it should be borne in mind that those branches nearest the center of the tree will give the best results. More food material is directed into them and in consequence the inserted buds or grafts make a more rapid, satisfactory growth. If the tree is not in good shape for working; i. e., if no branches of desirable size and age are found in convenient place, the tree should be trimmed to a pollard, cutting the main branches back to stubs, and when shoots have started from these, they should be grafted or budded. In about six months from the time the adventitious buds have started, under average conditions, buds or grafts may be inserted.

The method of procedure depends upon the size and age of the tree and upon whether the tree is to be budded or grafted. In grafting, the portions above the point of insertion of the grafts must be removed at the time the operation is performed, while if a veneer-shield or annular bud is inserted, this is not the case. In top-working old trees only a portion of the branches should be worked at one time, for if the whole top be removed, the tree suffers a severe shock; it may be killed outright, if not, its vitality is much reduced. Two or three years must elapse before the whole top of an old tree can be worked over, removing and replacing a portion of the top each season.



CUT 1. Cions. 1-3 Curtis; 4-6 Van Deman.
7-8 Stuart,
1 Poor Cion. long, slender, pithy.
2-4-5 7-8 Cions from 1 yr. growth.
3 Cion partly one, partly two years old.
6 Cion with cut, back of tip.
8 Cion which bore fruit at a.

With young trees three or four years old or older, if of small size, the whole top can be removed at one time, and grafts or buds inserted in the main branches, or in some cases, in the trunk.

The practice of taking cions and buds from young trees which have never borne or from nursery stock cannot be too strongly condemned. They should be cut only from thrifty, vigorous, prolific trees. Even trees of the same variety differ in these things, and a thorough knowledge of what a tree will do and has done is the only true guide in the selection of cions. It is a well-known fact that desirable qualities can be reproduced and perpetuated by grafting. Furthermore, if grafts or buds be taken from good bearing trees, fruit may be secured from top-worked trees in two years, and the third year a considerable number of nuts is usually obtained. Cut I, Fig. 8, shows a graft from a Stuart tree which would, without doubt, produce nuts at an early date after insertion. The point (a) is where a nut was borne the past season.

Grafts should be selected from well matured stock of one year's growth. Cut I, Fig. 1, shows an undesirable cion. The wood is angular, small, the internodes long, and the pith large in proportion to the diameter. Either terminal portions of twigs may be used or portions back of the tip, but the buds should always be well developed, full and plump, Cut I, Figs. 2 and 6. For this reason grafts should not be cut from wood far back from the tip of the branch. As stated already, twigs of the previous season's growth are generally used, but cions composed partly of two-year-old wood may be used, provided the growth is not too large. Cut I, Fig. 3, shows one of these. Grafts are generally cut about five or six inches long and should be from one-quarter to three-eights of an inch in thickness.

It is best that the grafts be cut while still in a dormant state, and as noted later, inserted in the stock just before growth starts. The cions may be kept for a considerable length of time by placing them, loosely packed, in damp moss or saw dust, in a box. The box should be covered over with earth and the cions kept sufficiently moist to prevent drying out. The difference in the condition of the stock and cion, it should be understood, is not absolutely necessary, as good results are frequently obtained without these precautions, but in grafting the pecan a difference in dormancy is extremely desirable, and is an important factor in securing good results.

For bud sticks, well developed one-year-old branches, one-half to seven-eighths of an inch in diameter and on which the buds are well formed, are selected. Such sticks frequently show three buds at a node (Fig. 6), and if some misfortune should overtake one or two of these, there is still a chance of success, though the upper one being the strongest is generally the one which starts, provided it is uninjured and the bud takes. The degree of maturity of the bud is important and care should be exercised that only those which are plump, full and well developed, are used. It is easy to distinguish between desirable and undesirable buds.

GRAFTING.

Grafting should be done in spring or just at the time the buds start, from the middle of February to the middle of March being about the season for Northern and Western Florida. The preference is for the latter part of the season, provided there is not too much work to be done, because the growth will soon start and there is less danger of misfortune to the graft, and the conditions are more favorable for a good union. Trees may be grafted on the trunk if small. If of medium size, the operation should be performed on the main branches a little way from the trunk, and if large, the grafts should be inserted on the branches farther up from the trunk. The attempt should not be made to bud or graft over the whole top of a large tree in one season. Only a few branches should be worked each year, and in the course of three, four or five years, depending upon the size of the tree, the old top can be entirely replaced by the new variety.

Two methods of grafting may be used, cleft and whip or tongue, but the latter can only be used on small branches, (less than one inch) while the former method can be used on large stock. A modification of cleft grafting, known as cleft sap grafting, has been used in Florida with success. The latter method is used on the larger size of stocks and does not materially differ from cleft grafting, except that the clefts are made to one side of the center and frequently two are made in the stock in place of one. This latter method is to be preferred for the working of very large stocks. If the cuts are made to one side of the center, the pressure on the cion is very much lessened, whereas, if the cion is placed in the center of the stock, as in the ordinary method of cleft grafting, the tissue of the cion may be injured to such an extent as to prevent a union. However, it is by no means advisable to graft very large limbs, for the cut ends do not heal over readily. If left thus exposed for a considerable length of time, as must necessarily be the case, the germs of decay may find entrance and cause rotting of the portion, which will undoubtedly spread to the older wood. In view of this fact, it is not deemed advisable to graft branches which exceed two and one-half inches in diameter at the very outside.

The tools and materials required in the performance of the work are a grafting iron, a mallet, an ordinary budding knife, grafting wax and strips of waxed cloth. A good grafting wax may be made as follows:

Resin	6 lbs.
Beeswax	2 lbs.
Linseed oil	1 lb.

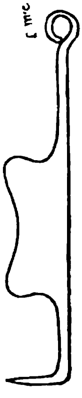
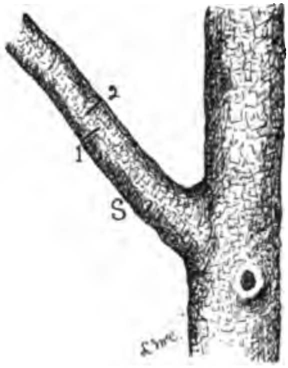


Fig. 2. Grafting iron.

The resin should be finely broken up; the beeswax should be cut in small pieces, and these together with the linseed oil should be placed over a slow flame and melted. This done, the liquid should be poured out into a bucket of water, and as soon as it is cool enough to handle, it should be pulled until it assumes a light color. To prepare the cloth, grafting wax is melted, old cotton is cut into strips, one inch wide or narrower, rolled on a square stick, six inches long, and dropped into the melted wax, or pieces of the cotton four or five inches wide may be used, wound around a stick as before, and afterwards cut up. In using grafting wax, the hands should be greased to prevent sticking.

Cleft Grafting. Having selected the branch for cleft grafting and the point at which the cions are to be inserted, the branch should be carefully and smoothly cut off. If the branch is large, this should be done after the manner illustrated in Figure 3, making the lower cut first, in order to



F.IG 3. Method of cutting large branches to prevent splitting.
1. First cut.
2. Second cut.
3. Stub.

prevent splitting. The stub (s) can then be cut squarely off just below the lower cut, i. e., at the point chosen. The limb is then split by using the grafting iron. If rapid work is to be done, grafts should be prepared beforehand and carried to the field, wrapped in damp paper. In preparing the cion, a sloping cut should be made about one and one-half inches long, cutting into the pith from a point one-half way up the cut down to the lower end. On the opposite side the cut should not be made to touch the pith, but should be confined to woody tissue throughout its whole length. The knife should have a keen, sharp edge. The cut should be clean, smooth and straight, and the cion should be left wider on the outer side. Start the cuts on each side of and just at a bud, as shown in Fig. 4.

Having made the cleft, it is opened with the wedge on the end of the grafting iron and the cion is placed in position. The cambium layers should be in contact. Slip the cion well down until the whole of the cut surface is within the cleft. If the stock is large enough insert two cions. After inserting the cion it should be firmly held in place by binding the stock with strips of wax cloth, after which a covering of wax may be placed over the cloth. The cut end of the stock should be covered, and if the cion be other than a terminal shoot, its distal end should be waxed also.

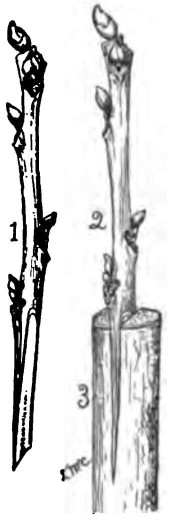


FIG. 4. Cleft-grafting.
1. Cion.
3. Stock, showing cleft.
2. Cion inserted ready for tying.

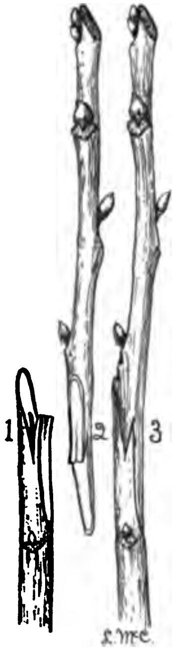


FIG. 5. Whip Grafting.
1. Stock showing cut.
2. Cion.
3. Stock and cion ready for bandage.

As already stated, branches which are to be worked by whip-grafting must be less than one inch in diameter. The method is illustrated in Fig. 5. A sloping cut, an inch and a half long, is made diagonally across the stock. A corresponding cut is made on the cion, a tongue is raised about the center of each cut by making another cut with the budding knife held almost parallel to the sides of the wood. The tongue is raised a little on both stock and cion and the two are shoved together. They should be securely bound with a strip of wax cloth and a layer of grafting wax should be spread over the whole, covering up all the cut surfaces to the exclusion of water, air and the germs of decay.

The cion and stock are preferably chosen of nearly the same size, but a cion somewhat smaller than the stock may be used, in which case the cambium layers along one side of the surface in contact should be placed opposite each other, and the projecting portion of the stock trimmed off.

BUDDING.

In Florida and perhaps most of the Southern States, more particularly those bordering on the Gulf, the time for budding is during the month of August and early September. During this season the atmosphere is generally quite moist, the buds are in good condition, the sap flows freely, and better results are obtained then than at any other time. Too much stress cannot be laid upon the condition of the stock and the weather, both in budding and in grafting. Upon these depend in a large measure the success of the work.

The same general rules apply to the top-working of trees by budding as by grafting. That portion of the branch above the point where the buds are inserted should not be cut off until the bud has either started or made a firm union with the stock. An attempt should not be made to work over the whole top of a tree at one time.

Two methods of budding pecan trees are in common use. The annular and a modification of it known as the veneer shield, to which reference has already been made in Bulletin No. 54. The latter method is probably the preferable.

It is very difficult to cut annular or veneer shield buds so that they will fit exactly. It is important that they should, and with the ordinary budding knife it is almost impossible, or can be accomplished only at the expense of a great deal of time and patience. A knife which will do the work satisfactorily should have two blades with their cutting edges in the same plane firmly attached to a common handle. A very satisfactory knife may be made from two ordinary budding knives and a piece of wood three-quarters of an inch square and four inches or so in length. To opposite sides of this the knives are attached by means of rivets or by firmly binding them with twine.

Mr. J. H. Girardeau of Monticello thus describes his budding knife, which has given excellent satisfaction: "Two budding blades are set in a wooden handle with their cutting edges exactly parallel and one inch apart." In this case the blades of the budding knives are removed from their handles and inserted in the wooden one.

Annular Budding.—By this method branches three-quarters of an inch or less in diameter may be worked. It is preferable that the stock and cion be of the same size. From the stock remove a ring of bark from one inch

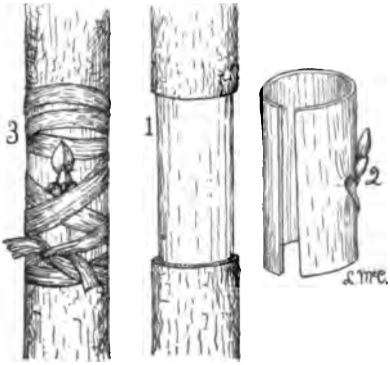


FIG. 6. Annular Budding.
1. Stock prepared for bud.
2. Bud.
3. Bud in place and tied.

to one and a half inches long. On the bud stick select a good plump bud and from it remove the bud by taking out a ring which will exactly fit that already made on the stock. To do this it is necessary to make a slit on the side of the ring opposite that on which the bud is. The ring of bark should then be carefully removed and placed upon the stock in the place already prepared for it. Following this the bud should be securely tied in place, using a strip of the waxed cloth already described. The bandage should be brought around the stock so as to cover the cuts, but the bud should be left exposed.

Veneer Shield-Budding.—If this method be used it is not essential that the stock and cion be of the same size, and so far as size alone goes almost any stock may be used. A square piece of bark is removed from the side of the stock. From the bud-stick a bud is cut in much the same way as already indicated for the annular method. If the stock is larger than the cion, it will be necessary to flatten out the cylinder of bark, which holds the bud. Having placed the shield of bark in position, it should be firmly tied. It is very essential that the buds be tightly tied in place.

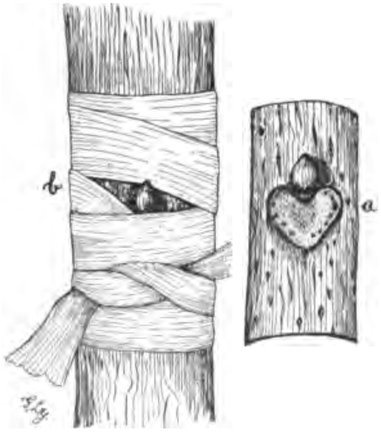


FIG. 7. Veneer Shield-Budding.
a. Bud cut.
b. Bud inserted and tied.
(Drawing by Miss G. L. Yocum.)
From Bul. 54. Fla. Exp. Station.

Frequently the buds will make a start the same season they are inserted, but often they act as dormant buds and do not begin growth until the following spring. In either case it is the usual practice to cut off or lop the top just before growth starts the next season. In removing the upper portion of the stock the cut may be made six or eight inches above the bud and the cut surface painted over with white lead. This stub may then be used during the first season at least, as a support for the young shoot. It may be tied to the stub, using a piece of soft twine.

THE CARE OF TOP-WORKED TREES,

For several months after the new top has commenced to grow the cions have but a slight hold upon the stock, and as the growth is usually very vigorous and the leaf surface great, considerable damage is frequently done by strong winds. To prevent this the young shoots may be tied together or fastened to other portions of the stock. If this be done, care should be taken that the twine used does not do injury by cutting into the wood. To obviate this a piece of burlap should be placed around the branch beneath the twine and the twine should be removed as soon as it has served its purpose. In some cases the top may be supported by lashing a pole against the side of the trunk and fastening the grafts to the upper part of this, or a pole may be driven into the ground at some distance from the trunk, fastened against a branch or stub of a branch above and used in the same way. After the top has grown sufficiently to take care of itself these posts can of course be removed. Plate I, Fig. 1, and Plate II, Fig. 2, show methods of supporting the top. Sometimes after the top has made considerable growth, and particularly if large branches are allowed to develop opposite each other, they are split apart and the whole top ruined. Fig. 1 shows this very undesirable growth of opposite branches, and Fig. 2 shows one of the best ways by which they may be held together. A bolt having a stout washer against the head is placed through the two branches. A second washer is placed on and the nut screwed up. This bolt will, in the course of a few years, be entirely covered. By this means the tree trunks are firmly bound together, and this same plan may be used to save branches which have partially split apart.

SUMMARY.

1. In seedling pecan groves there are frequently many trees which are unprofitable because of the small, inferior nuts produced. They may be made profitable by top-working them.
2. Cions should be cut only from bearing trees of good varieties.
3. Top-working may be performed by grafting in February and March, or budding in August and September.
4. The most satisfactory method of grafting is the ordinary cleft graft or a modification of it known as cleft sap grafting.
5. Two methods of budding may be used: the annular and veneer shield, but the latter is the more useful.
6. The new branches should be supported until they have become firmly attached.
7. Top-worked trees commence to bear when the tops are two years old.

The methods used in top-working trees may be used in nursery work as well, though the whip or tongue is the method of grafting most commonly adopted. Cions are inserted just at the small fibrous roots and the earth heaped up so as to leave only one bud exposed. Buds may be inserted anywhere from five or six inches to three feet above the crown.

H. HAROLD HUME.

EXPLANATION OF PLATES.

PLATE I.

1. Top-worked tree, showing points at which cions were inserted and pole used for support.

2. Method of holding trunks together by means of a bolt.

3. Budded tree with top removed to throw all nourishment into new top.

4. Pecan shoots inarched.

PLATE II.

1. Top-worked tree, var. Curtis, showing undesirable branching from stock, likely to be split by wind.

2. Method of supporting grafts by means of large posts.

3. Method of working over a large tree by cutting back and grafting branches. Var. Rome.

PLATE III.

Seven year trunk bearing a two year top. 23x20 ft. Var. Van Deman.

1. Tree without foliage. Dark spots are nut husks.

3. Tree in leaf.

2. Close view of union. Note where a large branch was removed.

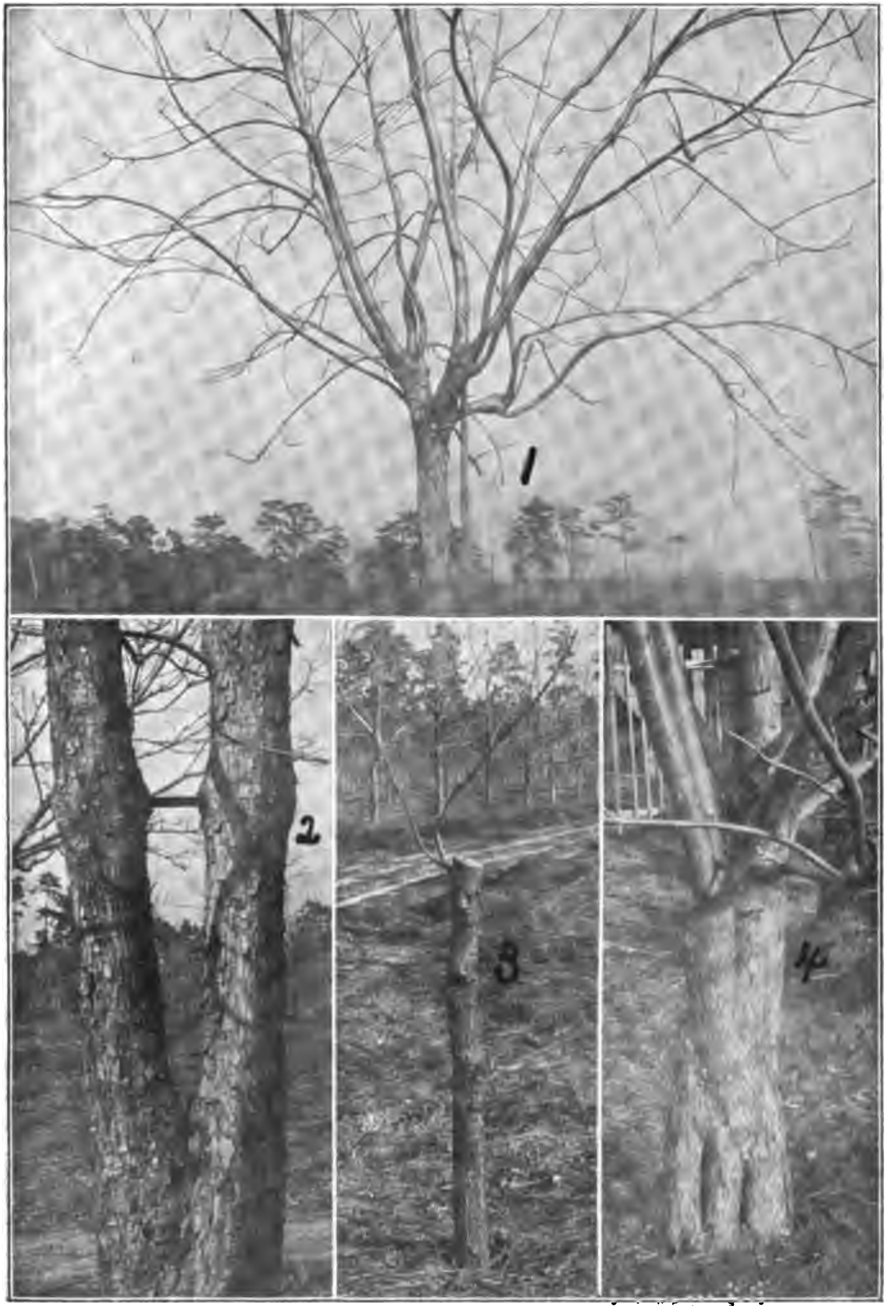


PLATE L

PLATE II.

PLATE III.—VAN DEMAN.

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BULLETIN No. 58. JUNE 1901.

FLORIDA AGRICULTURAL EXPERIMENT STATION.

POMELOS.

By H. HAROLD HUME.

The Bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

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POMELOS.

GENERAL DISCUSSION.

THE NAME—The name *pomelo* (*pl. pomelos*), as applied to the fruit under consideration, is the one now recognized by all horticultural writers and has been adopted by the United States Department of Agriculture, the American Pomological Society and the Florida State Horticultural Society. The word has been variously spelled pummelo, pumalo, pumelo, pumelow, etc., but the name and spelling as adopted in this publication are in accordance with the present usage of horticulturists.

In regard to the origin of the name Bonavia[1] makes the following remark: "The word pummelo is, of course, a corruption of the Dutch Pompelmoes through Pummelnose, by first making it Pummelos and then turning it into the singular *Pummelo.*" To the French the fruit is known by the name of Pompelmouse. Rumphius in 1750 applied the Dutch name pompelmoes to the fruit.

Commercially this fruit is known as *grape-fruit* and in market quotations reference is nearly always made to it under this name. This appellation was given because the fruit is so frequently borne in grape-like clusters of from three or four to a dozen and a half. A glance at the frontispiece, which represents a cluster of twelve, of which eleven are visible, proves that the name is not altogether inapplicable. Not only is the fruit known in the market as grape-fruit, but it is the name generally applied throughout Florida and the United States, and many people know it by none other. Whether the term—grape-fruit—will ever be superseded in common use by the correct horticultural name—pomelo—is extremely doubtful. When and where this cognomen was first used it would be difficult to say, but Risso and Poiteau[2] in their "History and Culture of Oranges," describe a variety of pomelo which they call "pampelmousse a grappe," and in reference to it made the following notes: "The author of the Flora of the Antilles has equally observed the pomelo cultivated in Jamaica, where the inhabitants call it grape-fruit. * * * * The fruits are gathered in clusters of from fifteen to eighteen on the branch, each of the size of the fist, spherical, firm, with a slightly rough skin of sulphurish yellow."

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[1] Oranges and Lemons of India and Ceylon. 223. 1888.
Edition by Du Breuil. 99. 1872.

Shaddock, variously spelled Shaddoc, Chaddock and Chadec, was an English sea captain, who, according to Miller, carried a variety of *Citrus decumana* to the West Indies, and from him it took the name *Shaddock*, by which it has since been commonly known and referred to by different writers. Bonavia in his work on the orange and lemons of India and Ceylon makes the name Shaddock synonymous with pomelo. In the section of Thomas' Fruit Culture on Subtropical Fruits, written by the late E. H. Hart, of Federal Point, Florida (1897), the name Shaddock is used, while pomelo, spelled pummelo in his article, is made synonymous.

However, we have no better name for this fruit than pomelo. It is of older origin than either of the others (if with some writers we allow the synonomy of Shaddock), the word from which it is derived having been in use a century and a half or more ago. The name pomelo has been adopted by the best authorities and it is by all means advisable that they be followed and that we have some constant name by which to designate the fruit. The fruit now designated by the name Shaddock, considered horticulturally, is entirely distinct from the pomelo, but, botanically considered, the two cannot be separated; they belong to one species. The term Shaddock is more properly applied to the large, pyriform or necked varieties. There are some other points of distinction between the two which may be mentioned. The fruit of the Shaddock is much the larger, often weighing fifteen pounds or more, the tree is smaller, the leaves on full grown trees are somewhat larger.

From the foregoing discussion of the common names, it will be seen that pomelo is the name given the preference, grape-fruit is synonymous, while Shaddock is relegated to a fruit botanically the same as the pomelo but horticulturally distinct.

HISTORICAL—No fruit of importance now grown in the United States has such a meagre American literature as the pomelo. Nor is this strange when we remember the fact that it is only within the last fifteen years or so that the pomelo has been regarded as a commercial fruit. For long years neglected while the whole attention of the fruit growers of our State was directed to the orange and all their energies put forth in bringing that fruit to perfection, it has only in very recent years taken its present position, to which the critical taste of fruit consumers has raised it.

The pomelo was brought to Florida together with other members of the genus Citrus by the Spaniards, who, under the leadership of Ponce de Leon, first landed upon the east coast of Florida in the year 1513. From that time until 1821 they disputed possession of this State with their enemies in the Old World and the aborigines of the country, except during a period of twenty years—1763-1783—during which time Great Britain controlled the territory.

During the Spanish regime different citrus fruits were introduced and cultivated in Florida. These, through the agency of the Indian, were carried into all parts of the State. To this day the common lime, generally known as the Florida lime, the rough lemon and the sour orange are to be found in southern Florida growing luxuriantly under such conditions as would lead one, ignorant of their origin and native home, to believe them indigenous to the soil on which they stand.

Following the time of introduction, in many groves and gardens throughout the State, pomelo trees were to be found annually laden with hundreds of fruit. By the inhabitants the fruit was considered refreshing and tonic, but that it might have a commercial value did not enter the minds of the owners, or if it did, transportation in its then crude state rendered any attempt to place this then unknown and unappreciated fruit on the market, with an expectation of profit, a precarious and uncertain undertaking. Consequently the ground beneath the trees during a certain portion of each year was covered with the yellow fruit left to rot in the sun.

Just at this point it is interesting to note that the fruit was either unknown to or disliked by horticultural writers, or confounded with the Shaddock even up to very recent years. Alexander Watson[1] in 1859 wrote the following: "Shaddock is a still larger fruit (than the citron)*, in form more resembling the orange, curious, but worthless." W. N. White[2], in 1868, says: "Pulp dry, sweetish or subacid, but not very desirable, except for its showy appearance." Rev. T. W. Moore, in his Hand Book of Orange Culture, 1881, does not mention it. Thomas in his Fruit Culturist makes no reference to it up as late as the edition of 1885. Wm. A. Spalding[3] in 1885 makes the following remark: "Meanwhile the Pumalo and its congeners when allowed growing space continue to load themselves down with fruit as large as foot balls. They are matters of wonder and that is all." Chas. Downing[4] (1885), under the head of Shaddock, has the following note: "The pulp is sweetish or subacid and the juice is rather refreshing. It is, however, more showy than useful, and certainly makes a magnificent appearance in a collection of tropical fruits."

Northern visitors to the State learned to know and like the pomelo and a certain demand was created by their desire for the fruit upon their return. Somewhere about 1880 or 1885 the first pomelos were shipped from the State, sold in New York and Philadelphia, and netted the shippers about fifty cents per barrel. This was the beginning and better prices were soon realized. The freeze of 1894-95 greatly reduced the crop and the small amount of fruit sold that year brought an enormous price, in some cases as much as $15 or $20 per box.

With a return of normal climatic conditions and a consequent increase in the quantity of fruit the price has dropped, the crop of the past season bringing from $4 to $7 per box for good fruit and less for inferior packages. Thousands of trees have been set out in Florida in the past four or five years and prices in the future will not equal

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1. The American Home Garden, page 363. 1859
2. Gardening for the South, page 384. 1868.
3. The Orange in California, page 89. 1885.
4. Downing's Fruits and Fruit Trees of America, page 579. 1885.
* ( ) Inserted by the author.

those in the past. Up to this time the supply has generally been inadequate to the demand, but with the increase in the amount of fruit a state of equilibrium between the supply and the demand will soon be reached. It is safe to predict that with a favorable climate the future price realized for pomelos will be much lower than at present. The tree is a heavy bearer; it is no harder to propagate and care for than an orange tree; it comes into bearing as early; heavy plantings have been made, then why will it not eventually be placed on the same basis with the orange? It undoubtedly will, unless some new channel is opened up for the consumption of the product.

To the careful, painstaking grower this need cause no uneasiness, for there will always be a good demand for a first-class fruit, well colored, well fed, carefully selected, well packed and placed upon the market in inviting shape.

At present it seems probable that Florida will retain control of the pomelo market for some time to come, probably indefinitely, if we are careful in maintaining the excellence of the product. *Let this be emphasized.* California cannot at present be considered a competitor, and whether that State will ever seriously affect our market is doubtful. Edward J. Wickson, in his Fruits of California (1900), refers to the status of the pomelo industry there as follows: "This citrus fruit achieved a very sudden interest in California because of the prices commanded by Florida pomelos about five years ago. When this supply to eastern cities was cut off by the serious frost injuries in Florida, there arose a passion for planting the trees in California, and a considerable acreage was planted, and as the tree is a very rapid grower, and precocious in fruit-bearing, large shipments were made in 1898, but the results were not satisfactory, and unless some new conditions should arise it is possible that the California pomelo passion may subside as rapidly as it uprose."

VARIETAL.

DESCRIPTION OF TREE—A tree upward of thirty feet in height, slightly thorny; bark smooth, grayish brown; branchlets angular or nearly round, green; young leaves sparsely pubescent, light green; mature leaves ovate, blunt pointed, smooth, dark green, with crenate margins and broadly winged petioles; flowers large, white, sweet-scented, borne in clusters; petals 4–5; stamens numerous;

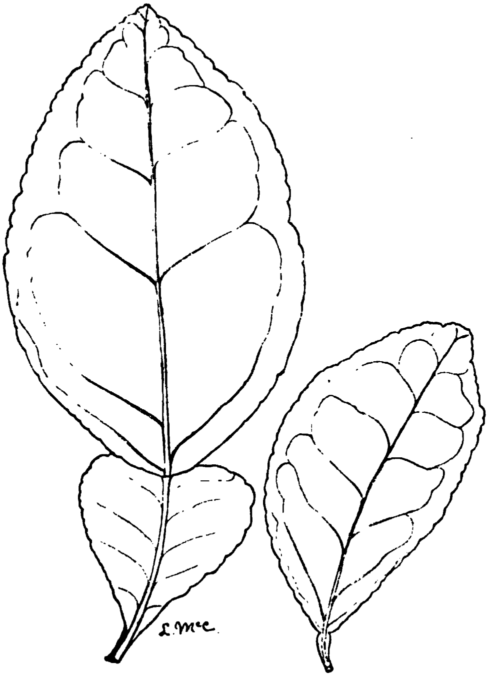

FIG. 1—Leaves of Pomelo one-half natural size. The leaf to the right is not typical, but such are sometimes found.

fruit a hesperidium, roundish oblate; flesh grayish green or pinkish; rind smooth, thick, bitter, not separating easily from the pulp; flavor a mingling of acid, bitterness and sweetness; seeds large, white, frequently winged, cotyledons white or whitish. Generally conceded to be a native of the Polynesian and Malayan archipelagoes. More tender than the sweet orange.

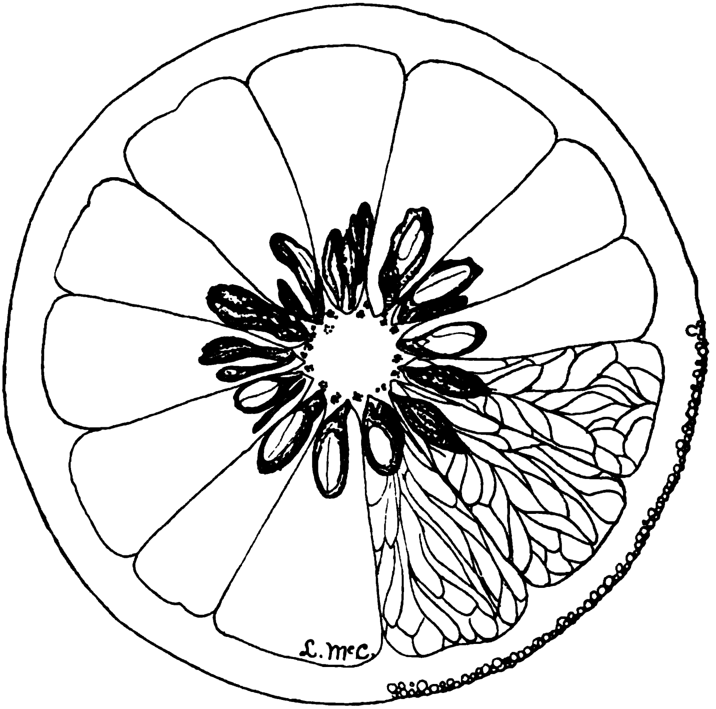

FIG. 2—Cross section of Manville Pomelo, three-fourths natural size, showing rind, sections, seed, juice sacks and oil cells of rind.

The tree is known scientifically as Citrus decumana Murr., but the author owing to a limited station library has been able to give only the following synonomy:

Limo decumanus Rump. Herb. Amboyn. II: 96. 1750.
Citrus decumana Murr. in Linn. Syst. Veg. Ed. XIII: 508. 1774.
Citrus decumana Wild. Enum. Plant. 807. 1809.
Citrus aurantium decumanum Gall. Traite du Citrus, var. 37. 1811.

VARIETIES—It is the object of this section of the Bulletin to give as faithful an idea as possible of some of the pomelos grown in the State at the present time. Full descriptions of these fruits, such as may be found in standard works for other fruits, are almost entirely lacking, and except for brief notes in the catalogues of our leading nurserymen, those unacquainted with the fruits are without information on the subject. It has been impossible to obtain specimens of all varieties grown in the State and it may be true that there are many seedling trees which produce fruit of as high a quality as any described in the following pages. The fact remains, however, that the planter to-day is dependent upon our nurserymen for his trees, and must at present make his choice from the following list:

Aurantium, Duncan, Excelsior, Hall, Marsh, Pernambuco, Tresca, Triumph, Royal and Walters, as these are all that are listed in the nursery catalogues on file in the department.

Attention must be called to two or three publications. The Report of the State Horticultural Society for 1896 contains a list of pomelos, with brief tabulated descriptions, and in Bulletin No. 8., Division of Pomology, U. S. D. A., a similar list may be found. The late lamented P. W. Reasoner, in Bulletin No. 1, Division of Pomology, U. S. D. A., listed and briefly noted several varieties.

Aurantium. Page 409, Plate I.

Form oblate; size 3½ inches x 3⅞* inches, frequently smaller; stem small; color light yellow; rind smooth, but with the oil cells slightly depressed; sections eleven, regular; flesh grayish green; bitter principle not marked or present only in a very slight degree; acidity medium; sweetness good; seeds thirty-five, of medium size; season late.

The Aurantium is a hybrid variety first sent out by James Mott, formerly of Orlando. The date is not certain, but Professor Brackett, United States Department of Agriculture, Division of Pomology, forwarded me a copy of the description made of this fruit in the Department in 1895. It was probably introduced some time previous to that date.

Specimens received from Reasoner Brothers, Oneco, Fla., and Mr. A. A. Gardner, Fort Myers, Fla. This variety, as already noted, is held to be a hybrid between the sweet orange and the pomelo, and the character of fruit—so different from that of the pomelo—gives color to this view.

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* In all cases the diameter from base to apex is given first.

The quality is good, but falls short of the standard of excellence for pomelos.

DeSoto. Page 411, Plate II.

Form oblate; size 3⅞ inches x 4⅞ inches; stem stout; base creased; rind medium thick, compact; color light yellow: oil cells very slightly elevated; sections fifteen large, irregular; flesh light grayish; juice sacks large, well filled, irregular; bitterness decidedly marked; acidity medium; flavor and quality both good, though slightly lacking in character; seeds forty-three, wedge shaped, large and plump; season late.

Specimens from Mr. John Thomson, Clearwater, Fla.

This variety was selected by Mr. Thomson from a number of seedling trees grown from seed obtained in DeSoto County.

Duncan. Page 413, Plate III.

Form oblate; size 3⅜ inches x 4⅛ inches, 4½ inches x 5¼ inches; stem large; calyx segments broad, blunt; apex slightly scarred; rind medium thick, firm; oil cells large, sunken; sections fourteen; flesh light grayish green; juice sacks closely packed, large; bitterness well marked; acidity and sweetness good; core ⅝ inch across, somewhat open; seeds* five or more, large, plump, blunt, not winged; season late.

A fruit of very good quality, originated by A. L. Duncan, Dunedin, Fla.

Specimens from Mr. G. L. Taber, Glen St. Mary, Fla., borne on a small tree on trifoliata stock (first fruiting). Fruits of larger size than those indicated by the measurements given above are very frequently obtained.

Excelsior. (*Excelsior Late.*) Page 411, Plate II.

Form oblate; size 4 inches x 4¾ inches; color lemon yellow; rind very slightly pitted; oil cells large, slightly sunken; sections thirteen, large, irregular; flesh light grayish; bitter principle well marked; acidity normal; quality good; seeds thirty-one, wedge-shaped, large, plump; season late.

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* This number is probably decidedly under the average.

This variety originated in Florida, the parent tree being a native seedling. Introduced by C. M. Marsh, Lakeland, Fla.

Specimens of fruit received from John Thomson, Clearwater, Fla., and C. M. Marsh, Lakeland, Fla.

Hall (*Silver Cluster*). (*Halls*) (*Klemm's Silver Cluster*). Frontispiece.

Form oblate; size 4⅛ inches x 4⅝ inches, or larger; stem large; color light yellow, but slightly darker than that of most pomelos; base smooth, or sometimes slightly creased; rind 3/16 inch thick; oil cells slightly indented; sections fourteen, large, variable in size; bitter principle strongly developed; acidity and sweetness well marked; juice almost transparent; seeds thirty-two, small, roundish, plump, quite a number aborted; season February–March.

There has been considerable discussion over the origin of this variety, but it seems to be a fact well established that it was originated by John W. Hall, of Caloosa, Fla. The original tree was grown from seed sown by him when he first came to the State about sixteen years ago. The synonomy as given above may be open to some objections, but in naming it the credit has been given to Dr. Hall, to whom it is believed to be due. The frontispiece is from a photograph of one of the clusters.

Specimens of the fruit received from Mr. A. M. Klemm, Winter Haven, Fla. A good variety.

Josselyn. Page 413, Plate III.

Form roundish-obovate; size 3⅓ inches x 3½ inches; stem medium; color yellow, darkest of all the varieties which have come under observation; rind smooth; oil cells slightly sunken; sections twelve, rather irregular, dividing tissue thick; flesh grayish green; pulp melting; bitterness strongly marked; acidity and sweetness well developed; core ½ inch in diameter, solid; seeds forty-eight, whitish, small and plump; season December–January.

This variety was introduced by Messrs. J. W. and F. D. Waite, of the Magnolia Nurseries, Belleview, Marion County, Fla., in 1888. The original tree stood in the old Josselyn grove at East Lake, on Lake Weir.

Specimen of fruit from Mr. G. L. Taber, Glen St. Mary, Fla.

Manville. (*Manville's Improved.*) Page 409, Plate I.

Form oblate; size medium to large, 3⅝ inches x 4⅛ inches; stem small; color lemon yellow; rind ¼ inch thick, smooth, the oil cells being flush with the surface or only slightly sunken; sections thirteen, large, fairly regular; flesh light grayish green; juice sacks large, irregular; bitterness well marked; acidity and sweetness good; core ⅝ inch in diameter, compact; seeds sixty to seventy, large; season late.

In relation to origin of this variety, Reasoner Brothers, write as follows: "Manville's Improved was sent us by the late A. H. Manville, from East Florida, years ago."

Specimens of fruit received from Reasoner Brothers, Oneco, Fla. Thus far this variety has not been catalogued, but the fruit appears to be very desirable.

Marsh (*Marsh's Seedless*). Page 415, Plate IV.

Form oblate roundish; size 3⅛ inches x 4⅞ inches, 3½ inches x 4½ inches, 3⅝ inches x 4⅞ inches; stem small; color light yellow; rind ⅛ inch thick, smooth; oil cells small, scarcely or not at all indented; sections thirteen, regular; partitions thin; juice sacks small; flesh grayish green; bitter principle not strongly marked; acidity and sweetness medium; pith ⅝ inch in diameter, open; seeds two to six, or none, large, plump; season February–March.

This variety was introduced by C. M. Marsh, Lakeland, Fla., about seven or eight years ago. The original tree was a seedling, growing in Lakeland, and was at the time of the freeze fully sixty years old. This pomelo has not the distinct, pronounced flavor of the typical fruit, but the quality is good, and the fact that it is so nearly seedless is a very desirable feature.

Specimens of the fruit received from C. M. Marsh, Lakeland, Fla.; C. W. Butler, St. Petersburg, Fla., and John Thompson, Clearwater, Fla.

McKinley. Page 417, Plate V.

Form oblate, or slightly oblate conical; size 3⅞ inches x 4¾ inches; color pale yellow; rind smooth, thin; oil cells large, conspicuous, scarcely indented; sections fourteen, large, slightly irregular; bitterness marked; acidity normal; sweetness good; quality of the best; core ¾ inch in diameter, pithy; seeds sixty-two, wedge-shaped, large; season late.

This is a pomelo of considerable merit, and worthy of propagation. Fruit from a seedling tree in the grove of A. A. Gardner, Fort Myers, Fla.

Nocatee. Page 419, Plate VI.

Form roundish or somewhat oblate; size small, 2⅜ x 2¾ inches, 2½ inches x 3 inches, 2⅝ inches x 3¼ inches; stem small; calyx small; apex slightly marked; color lemon yellow, occasionally somewhat deeper; rind ⅛ to 3/16 inch, easily detached; oil cells minute, slightly indented; sections twelve, variable in size, separating easily; flesh yellowish gray; tissue thin, translucent; juice almost transparent; acidity medium; bitter principle lacking; juice sacks small, short, plump, in shape resembling those of the tangerine; flavor a commingling of pomelo and tangerine; pith small, ⅜ inch in diameter; seeds three to twenty-three, small, slightly winged at the tip; cotyledons white or green, or partly green and partly white; season late; a good keeper.

This variety appears to be a well-marked hybrid between the tangerine and the pomelo, and I have placed it with the pomelos because the fruit in general appearance more closely resembles that fruit.

It originated at Nocatee, Fla., and Mr. T. J. Watkins, the owner of the tree, gave me the following notes regarding it: "The original tree is about twenty years old, and somewhat larger than an average sour orange tree of the same age. It is a hybrid of accidental origin, showing marks of grape-fruit, tangerine, and bitter-sweet orange. It is a distinct type, having fruit, bloom, wood, habit of growth and leaf different from all others, and is as easily recognizable as the tangerine or grape-fruit. It is a strong, vigorous grower, with limbs long and somewhat slender. The leaves are medium size, broad, slightly bent upward from midrib and slightly curved backward, giving a shape bearing some resemblance to an apple leaf, but in color and texture it resembles the leaf of the common orange. In habit of growth it is loose, open-headed, and the foliage less dense than a grape-fruit or common orange. The wood is almost thornless and the tree prolific, being laden with fruit every year. All characteristics of the tree and fruit are retained in budded trees. * * * * Growth of budded trees has been more rapid and vigorous than that of grape-fruit buds under similar conditions.

"The fruit is of medium size, running about 150 to the box, in color a clear, pure yellow; has few seeds, many of the fruits being entirely seedless; has loose rind, separating from the fruit a little less easily than tangerine's. * * * It is good any time after December, and will hang on the trees until August, but reaches full maturity about April, when it develops a rare combination of rich and delicate flavor."

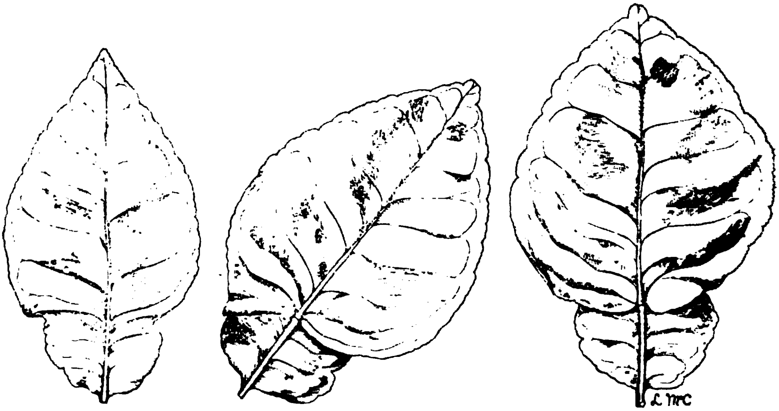

Fig. 3.—Leaves of Nocatee Hybrid Pomelo, one-third natural size. These leaves were taken from a single twig.

The leaves of this variety are different from those of the orange or grape-fruit. On some leaves the wings are entirely absent. In others the wing is cut in on one side only, leaving the other entire, while other leaves have a well-marked wing on both sides. Fig. 3 represents the three types of leaves somewhat reduced. The drawings were made from actual specimens on young shoots.

The fruit is certainly unique and interesting, and possesses a considerable degree of merit.

Pernambuco. Page 421, Plate VII.

Form oblate; size 3¾ inches x 4¾ inches, 3⅞ inches x 4½ inches; stem stout; calyx medium in size; color very light yellow; rind ¼ inch thick, compact, closely attached, smooth; oil cells large, sunken; sections twelve, uniform in size, well defined; flesh grayish green; bitterness well marked; acidity and sweetness good; character well marked; seeds sixty to seventy-five, whitish, wedge-shaped, irregular; season late.

This variety was imported by the United States Department of Agriculture from Pernambuco, Brazil. It is a variety of very fine quality.

Specimens of fruit received from Reasoner Brothers, Oneco, Fla.

Royal. Page 421; Plate VII.

Form slightly oblate; size 3 inches x 3½ inches, 3 inches x 3⅝ inches; stem stout; color light yellow; rind ⅛ inch thick; oil cells small; sections eleven or twelve, small, regular; flesh grayish green; bitter principle almost entirely lacking; acidity medium; sweetness good—can be eaten from the hand as an orange; seeds forty, grayish in color, roundish and plump; core ¾ inch in diameter, pithy; season medium, early.

This fruit was introduced by Reasoner Brothers, of Oneco, Fla., the original tree being a seedling growing in their neighborhood, the seed from which it grew having come from the West Indies.

Specimens of fruit from Reasoner Brothers, Oneco, Fla.

The fruit is quite desirable, but lacks the character of the pomelo. The tree is a good bearer, probably a hybrid.

Standard (*Indian River*).

Form oblate; size large, 4¼ inches x 5 inches; stem small; base slightly creased; color very light yellow; rind ⅜ inch thick; oil cells large, slightly depressed; sections thirteen, large, rather irregular; flesh grayish green; bitterness marked; acidity and sweetness normal; pulp melting; juice plentiful; juice sacks large; seeds forty-nine to fifty-nine, large, long, creased; core ⅓ inch, open; season January–March.

The origin of this variety is unknown. C. T. McCarty, Ankona, Fla., from whom the specimens were secured, wrote as follows regarding it: "This pomelo is known here as Standard, or Indian River; I don't know its origin. It came here from Rockledge sixteen years ago."

This fruit is of very fine quality indeed.

Triumph. Page 415, Plate IV.

Form oblate or slightly oblate-oblong, slightly flattened at base and apex; size 3⅜ inches x 4 inches; stem small; color light yellow; rind very smooth, ⅛ inch thick; oil cells slightly depressed; sections eleven; bitter principle not so strongly marked as in some; acidity and sweetness normal; juicy; pulp melting; seeds thirty-seven, medium, plump, roundish; core ⅜ inch in diameter, open or pithy; season medium early.

Mr. J. H. Fessenden, Tampa, Fla., under date of March 6, 1901, wrote as follows regarding the origin of this variety: "The buds for the Triumph grape-fruit were taken from a seedling standing in the yard of the Orange Grove Hotel at this place. The fruit was noted for its excellent quality. The propagation of it was commenced in 1884. The parent tree was killed by the freeze of 1894–'95. This is a good fruit, of medium size, the flavor being very pleasant and sprightly."

Specimens of fruit received from Dr. F. W. Inman, Winter Haven, Fla.

Walters (*Walter*). Page 417, Plate V.

Form oblate; size 3¾ inches x 4⅛ inches; stem small; color pale yellow; rind smooth, ¼ inch thick; oil cells almost flush with the surface; sections thirteen, large; bitter principle strongly marked: acidity and sweetness good; quality very good; seeds fifty-eight, large, plump, wedge-shaped or irregular; core ¾ inch in diameter, solid; season medium.

Mr. F. D. Waite, manager of the Manatee Lemon Company, Palmetto, Fla., gave the following notes on the origin of this variety: "We * * * * assisted Mr. Walters in introducing the Walters. The tree was only one mile from my home in Belleview, Marion County. * * * * The Walters was introduced in 1887."

Specimens of fruit received from Dr. F. W. Inman, Winter Haven, Fla. In habit of growth this tree very closely resembles the Hall, and by some they are thought to be the same, but the origin of the two is entirely different, and an examination of the seeds (Fig. 4) shows that they are entirely distinct. The figure represents the seeds taken from a Walters and Hall fruit and photographed side by side, Walters on the left, Hall on the right.

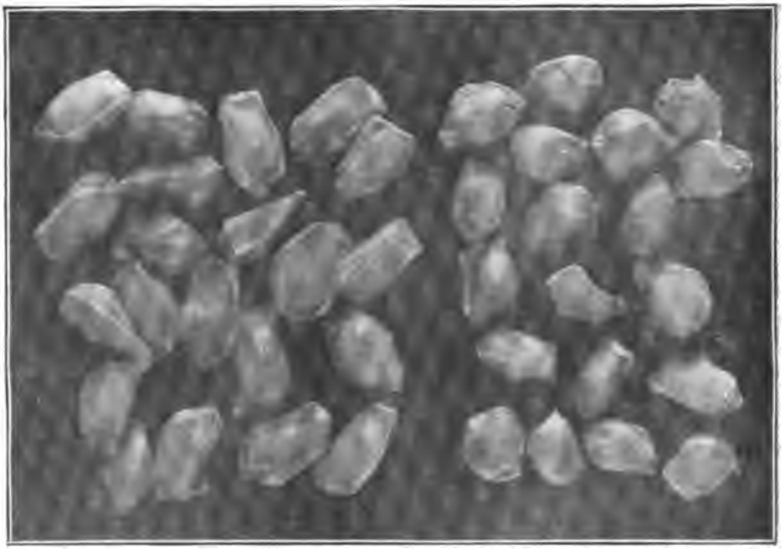

FIG. 4.—Seeds of Walters and Hall Pomelos, showing that these varieties are distinct.

ESTIMATION OF VARIETIES.—The pomelo, like all other citrus fruits grown in the State, is in a very large measure a reflection of the care and food given the tree. Upon these depend juiciness, amount of *rag*, thickness of rind, and quality in general, more than upon any other factors, though the age of the tree is also important, as the best fruit can not be expected until the tree has borne several crops.

The fruit which has been received at the Department came from many different parts of the State, was grown under as many different conditions, and the age of the trees was quite variable. Hence it has been in some measure difficult to place a just estimation upon the different varieties. Had it been possible to secure a larger number of fruit from different points in the State, this might have have been overcome.

Last season the market called for a large pomelo—one which would pack forty-six to fifty-four or less to the box—and the demand was considerably less for smaller fruit, the price being correspondingly low. The fruit, to come well up to the standard of excellence, must have the characteristic pomelo flavor—a pleasant commingling of bitterness, sweetness and acidity. Dividing the varieties listed and described above according to strength of flavor, we find that DeSoto, Duncan, Excelsior, Hall, Josselyn, Manville, McKinley, Pernambuco, Standard and Walters have the flavor pronounced. The Triumph and Marsh are not so characteristic, but both are very desirable. Aurantium, Royal and Nocatee can not be classed as characteristic pomelos, and all are probably hybrids. DeSoto, Duncan, Excelsior, Hall, McKinley, Pernambuco, Standard and Walters rank as large: Manville and Marsh, medium to large; Triumph, medium; while Josselyn, Aurantium, Royal and Nocatee are classed as small for pomelos.

Every person has his preference, and probably no two will agree in regard to the choice of varieties. This can not be regarded as strange, because, to a very large extent, such things are a matter of personal taste. Of the large varieties the author would recommend Duncan, Hall, McKinley, Pernambuco, Standard and Walters. The Triumph is a good variety, as well as the Marsh, the latter being very desirable because of the small number of seeds. Of the smaller varieties Josselyn is the only one which is characteristic, but Aurantium, and especially the Nocatee, have considerable merit, though characteristically different from the true pomelo.

FERTILIZING.

ANALYSES.—The following analyses of the pomelo were made for the Horticultural Department by the Station Chemists, Prof. H. K. Miller and Prof. A. W. Blair. To them the sole credit of the work belongs, and since it is probably the first work of the kind done on this fruit, its importance goes without saying.

The fruit of the first four varieties was obtained from Reasoner Brothers, Oneco, Fla.; the fruit of the last two from Dr. F. W. Inman, Winter Haven, Fla. In each case the analysis was made from ten fruits, which were well developed and fully ripe.

TABLE No. 1.

LAB. NO.	VARIETY	Average Weight in Grams	Average Weight in Ounces	Average Diameter in Inches	Average Number Seeds	Pulp, per cent.	Rind, per cent.	Seeds, per cent.
1234	Royal	541.48	19.1	3.20	46.4	69.32	27.23	3.45
1235	Pernambuco	742.77	26.2	3.75	61.0	68.52	28.05	3.43
1236	Manville	487.62	17.2	3.10	67.2	74.72	20.93	4.35
1237	Aurantium	430.92	15.2	3.00	37.3	68.60	28.29	3.11
1250	Walters	721.34	25.4	3.75	56.0	68.64	28.22	3.14
1251	Triumph	534.60	18.8	3.15	43.3	65.16	31.82	3.02

Table No. 1 gives the average weight in grams and ounces, the average diameter of the fruit in inches, the average number of seeds and percentage of pulp, rind and seed in each variety. From this it will be noticed that the weights of the Pernambuco and Walters are about the same, that the Royal and Triumph average nearly the same number of ounces, though in fact the Triumph usually runs larger than does the Royal. Between the Manville and the Aurantium there is in weight a difference of two ounces. The number of seeds in the different varieties varies from forty-three to sixty-seven. The largest percentage of pulp —74.72—was contained in the Manville; the Royal, Pernambuco, Aurantium and Walters were about the same, 68–69, while the Triumph dropped to 65.16 per cent. The variety having the least percentage of rind was the Manville, the Royal coming second, while Pernambuco, Aurantium and Walters were about the same, 28, and this particular lot of Triumph had 31.82 per cent. rind. This is probably accounted for by the fact that the fruit was gathered from young, vigorously growing trees, bearing only their first or second crop. The lowest percentage of seed was found in the Triumph, while the remaining varieties range in this order: Aurantium, Walters, Pernambuco, Royal, Manville. From this table little can be said regarding the merits of the different varieties in relation to the relative amounts of pulp and rind, because the trees from which the fruit was gathered were not of the same age, nor had they been given the same treatment.

TABLE No. 2.

VARIETY	LAB. NO.	SUBSTANCE	P_2O_5 per cent.	K_2O per cent.	N per cent.
Royal............... 1234	1238	Pulp	.033	.211	.081
	1239	Rind	.029	.330	.108
	1240	Seed	270	.430	.980
Pernambuco......... 1235	1241	Pulp	.050	.195	.074
	1242	Rind	.034	.230	.076
	1243	Seed	.360	.460	1.130
Manville 1236	1244	Pulp	.042	.212	.058
	1245	Rind	.043	.350	.080
	1246	Seed	.320	.450	.960
Aurantium 1237	1247	Pulp	.045	.202	.055
	1248	Rind	.042	.307	073
	1249	Seed	.330	.445	.850
Walters............. 1250	1252	Pulp	.046	.212	.101
	1253	Rind	.030	.260	.098
	1254	Seed	.310	.440	1.050
Triumph 1251	1255	Pulp	048	.226	.085
	1256	Rind	.030	.240	.096
	1257	Seed	.301	.456	1.030

Table No. 2 gives the percentage of phosphoric acid ($P_2 O_5$), potash ($K_2 O$) and nitrogen (N) in the pulp, rind and seed. In every instance it will be noticed that the percentage of phosphoric acid, potash and nitrogen is highest in the seed. The percentage of phosphoric acid is in almost every instance higher in the pulp than in the rind, while the percentage of potash is always higher in the rind than in the pulp. The percentage of nitrogen is higher in the rind than in the pulp, except in one variety, the Walters, and even there the excess is very slight, .003 of one per cent.

Table No. 3 shows the total percentage of phosphoric acid, potash and nitrogen in all the parts of the fruit, pulp, rind and seed combined. A glance at the table shows that the phosphoric acid varies from .040 per cent. to .056 per cent., that the potash varies from .213 per cent. to .251 per cent., and the nitrogen from .085 per cent. to .119 per cent. The average percentages in the six varieties are as follows: .050 per cent. phosphoric acid, .237 per cent. potash and .110 per cent. nitrogen.

TABLE No. 3.

VARIETY	$P_2 O_5$ per cent.	$K_2 O$ per cent.	N per cent.
Royal 1234	.040	.250	.119
Pernambuco 1235	.056	.213	.111
Manville 1236	.054	.251	.102
Aurantium 1237	.053	.239	.085
Walters 1250	.049	.233	.129
Triumph 1251	.050	.237	.117
AVERAGE	.050	.237	.110

To make practical application of this table we will assume that the average weight of a box of pomelos is 80 pounds and find the amounts of the three important plant constituents removed by ten boxes of fruit, 800 pounds. In ten boxes there will be taken from the grove and subsequently sold in New York, Boston or some other market .40* pounds phosphoric acid, 1.90* pounds potash and .88* pounds nitrogen. Now, if each tree bears ten boxes of fruit, these amounts must be supplied to make fruit alone, to say nothing of the amounts required to make wood growth.

Suppose we select as our fertilizing materials acid phosphate, analyzing 14 per cent available phosphoric acid, high grade sulphate of potash, analyzing 50 per cent available potash, and nitrate of soda, analyzing 15 per cent nitrogen. Of these materials there will be required as follows: Acid phosphate 2.85 pounds (2 lbs. 13½ ozs., approximately); high grade sulphate of potash 3.8 pounds (3 lbs. 12¾ ozs., approximately), and nitrate of soda 5.86 pounds (5 lbs. 13¾ ozs., approximately.) This gives in all 12.51 pounds (12½ lbs. approximately) of fertilizer. If other fertilizing materials are used the number of pounds will vary, but such amounts must be used so as to supply phosphoric acid, potash and nitrogen as given above; that is a sufficient amount must be supplied to give .40 pounds phosphoric acid, 1.90 pounds potash and .88 pounds nitrogen, *if ten boxes of fruit are produced* by the trees, or *one-tenth of these weights for each box;* namely, .04 pounds phosphoric acid, .19 pounds potash and .088 pounds nitrogen.

Of these amounts a certain portion is gathered from the soil, but in giving the weights as above no allowance has been made for the materials obtained from this source. It is deemed best to supply these amounts for the fruit and make the necessary deduction from the amounts required to make wood growth. On the other hand, no increase has been made to counterbalance the losses from leaching, etc. All these things have to be taken into account. It is a noteworthy fact, however, that the grower who fertilizes heavily has the largest crop, the best fruit and realizes the most from his trees. Liberality in fertilizing may be taken as an indication of the grower's care in all things pertaining to the production of a first-class fruit.

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* Obtained by multiplying by the average percentage at bottom of Table No. 3.

FERTILIZERS—The experience of most growers points to the use of chemical fertilizers alone for all citrus trees. The grove fruits more heavily, a better quality of fruit is obtained and the trees are certainly in a healthier condition. Where large amounts of organic fertilizers are used, *die-back* will almost surely affect the trees, and ammoniated* fruit or fruit containing a large amount of *rag* and of poor shipping and keeping quality is the result. A pomelo, as already stated, is in quality a reflection of the food and cultivation given the tree on which it was borne.

Fertilizers should be applied at least twice a year, just before or at the time of the commencement of growth and again in summer, about the month of July. During the winter the roots of citrus trees in some parts of the State continue growth, and it would appear advisable in those parts to make a third application in the fall. If nitrate of soda be used as a source of nitrogen it is best to apply it in three separate dressings, in March, May and July, and the phosphatic and potash fertilizers twice, as recommended above. Nitrate of soda moves readily through the soil and may be lost to the tree unless appropriated in a comparatively short time after being placed in the soil.

The leaching of fertilizers is in a large measure prevented by the presence of humus, and pains should be taken to maintain a very considerable quantity of this material in the soil. It may be done either by mulching or by the growing of cover crops.

ACKNOWLEDGMENTS.

To Prof. H. K. Miller and Prof. A. W. Blair the author desires to again acknowledge his indebtedness for the chemical analyses shown in the tables.

Reasoner Brothers, Oneco, Fla.; G. L. Taber, Glen St. Mary, Fla.; John Thomson, Clearwater, Fla.; A. A. Gardner, Fort Myers, Fla.; Dr. F. W. Inman, Winter Haven, Fla.;

---

* A term frequently applied to fruit showing evidences of *die-back*.

C. W. Butler, St. Petersburg, Fla.; T. J. Watkins, Nocatee, Fla.; A. M. Klemm, Winter Haven, Fla.; F. D. Waite, Palmetto, Fla.; J. H. Fessenden, Tampa, Fla., and C. T. McCarty, Ankona, Fla., have kindly assisted with specimens and notes. Prof. G. B. Brackett, Pomologist United States Department of Agriculture, furnished descriptions of varieties on file in the Department. Each and all of these men have contributed to the completeness of the Bulletin, and the thanks due them are here expressed.

H. HAROLD HUME.

EXPLANATION OF FIGURES AND PLATES.

FRONTISPIECE. Cluster of Hall Pomelos.

FIG. 1. Leaves of Pomelo.

FIG. 2. Cross section of Manville Pomelo, three-fourths natural size.

FIG. 3. Leaves of Nocatee hybrid Pomelo, one-third natural size, showing variations.

FIG. 4. Seeds of Walters and Hall Pomelo. Proof that they are distinct varieties.

PLATE I. Aurantium and Manville Pomelos. In most cases the knife, 3¼ inches long, has been photographed with the fruit.

PLATE II. Excelsior and DeSoto Pomelos. The Excelsior to the left is scarcely typical.

PLATE III. Duncan and Josselyn Pomelos.

PLATE IV. Marsh and Triumph Pomelos. The former showing a cross section.

PLATE V. McKinley and Walters Pomelos.

PLATE VI. Nocatee hybrid Pomelos.

PLATE VII. Pernambuco and Royal Pomelos.

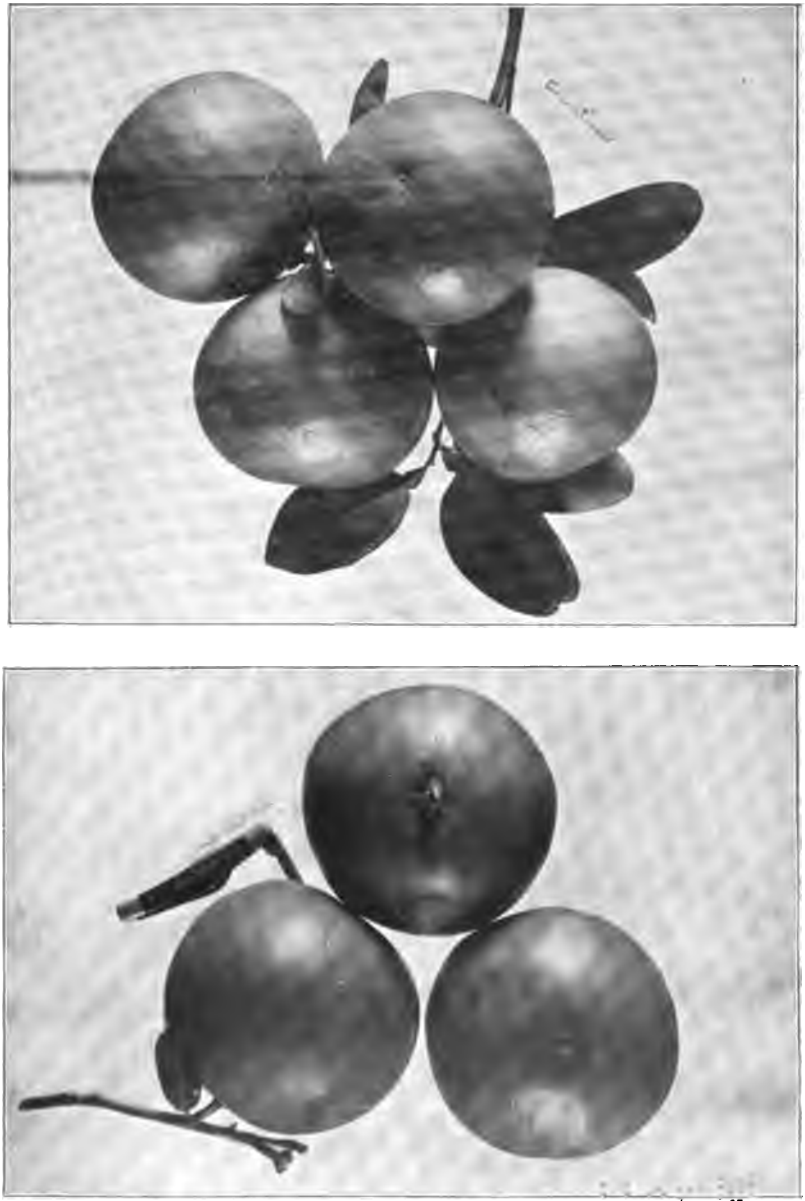

PLATE I. Aurantium diameter 3⅞ inches. Manville, diameter 4⅛ inches.

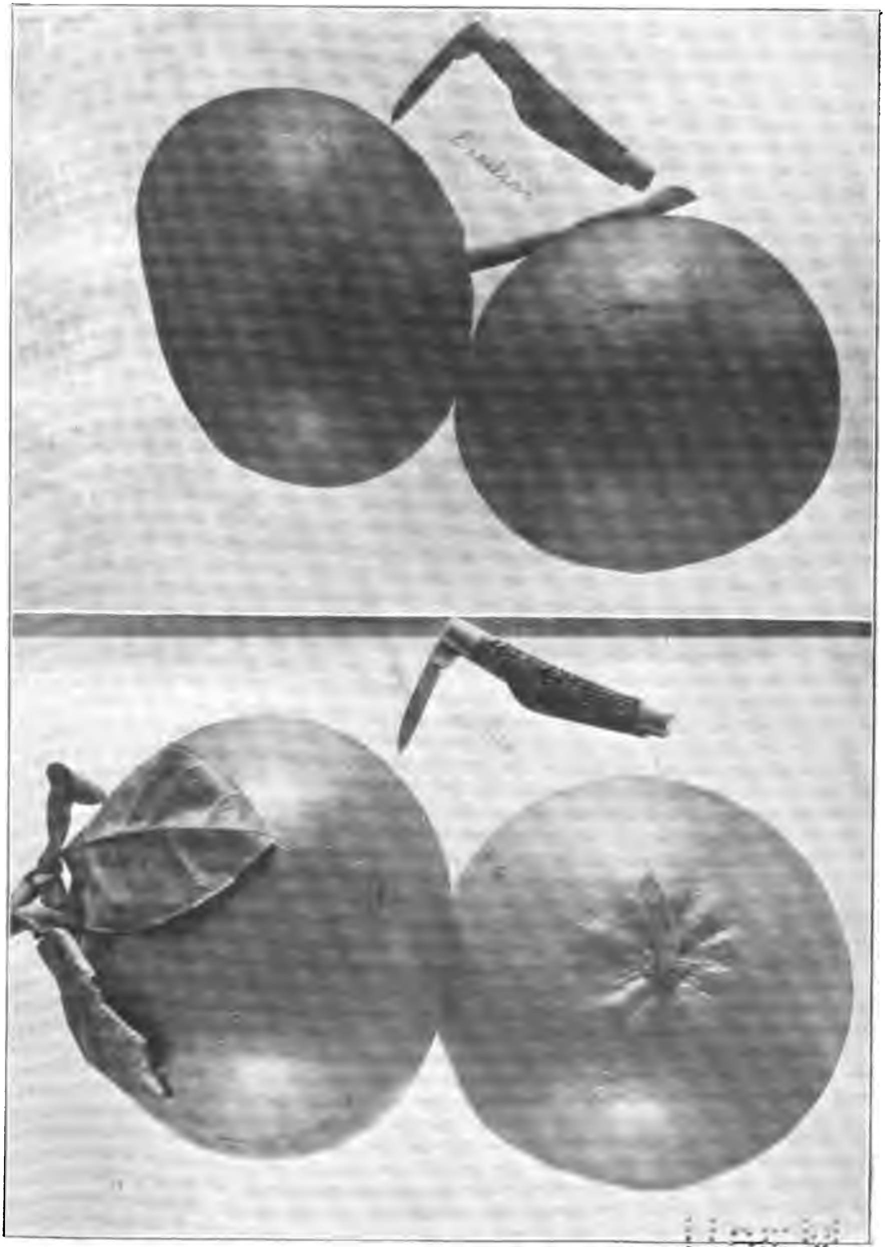

PLATE II. Excelsior, diameter 4¾ inches. DeSoto. diameter 4⅞ inches.

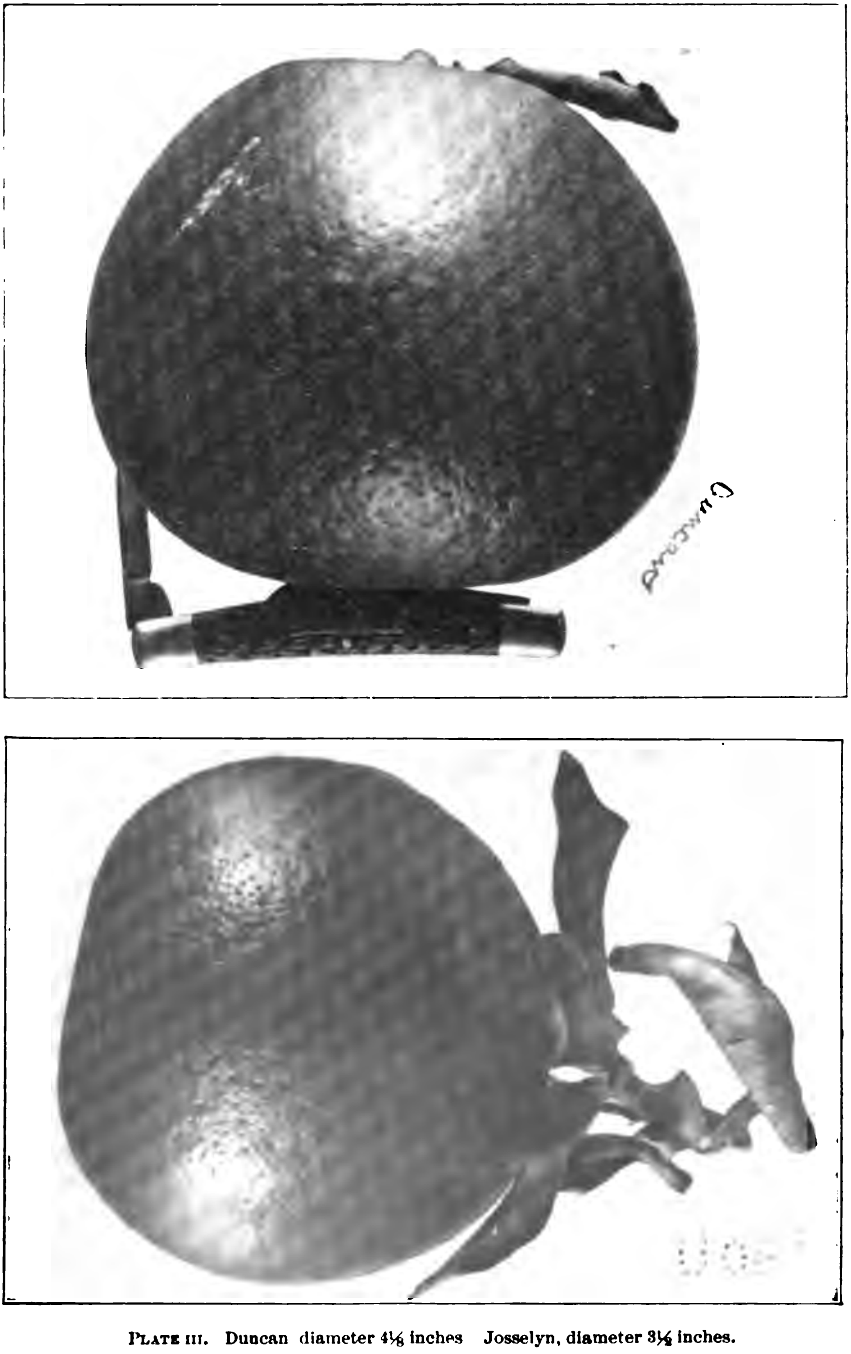

PLATE III. Duncan diameter 4⅛ inches Josselyn, diameter 3½ inches.

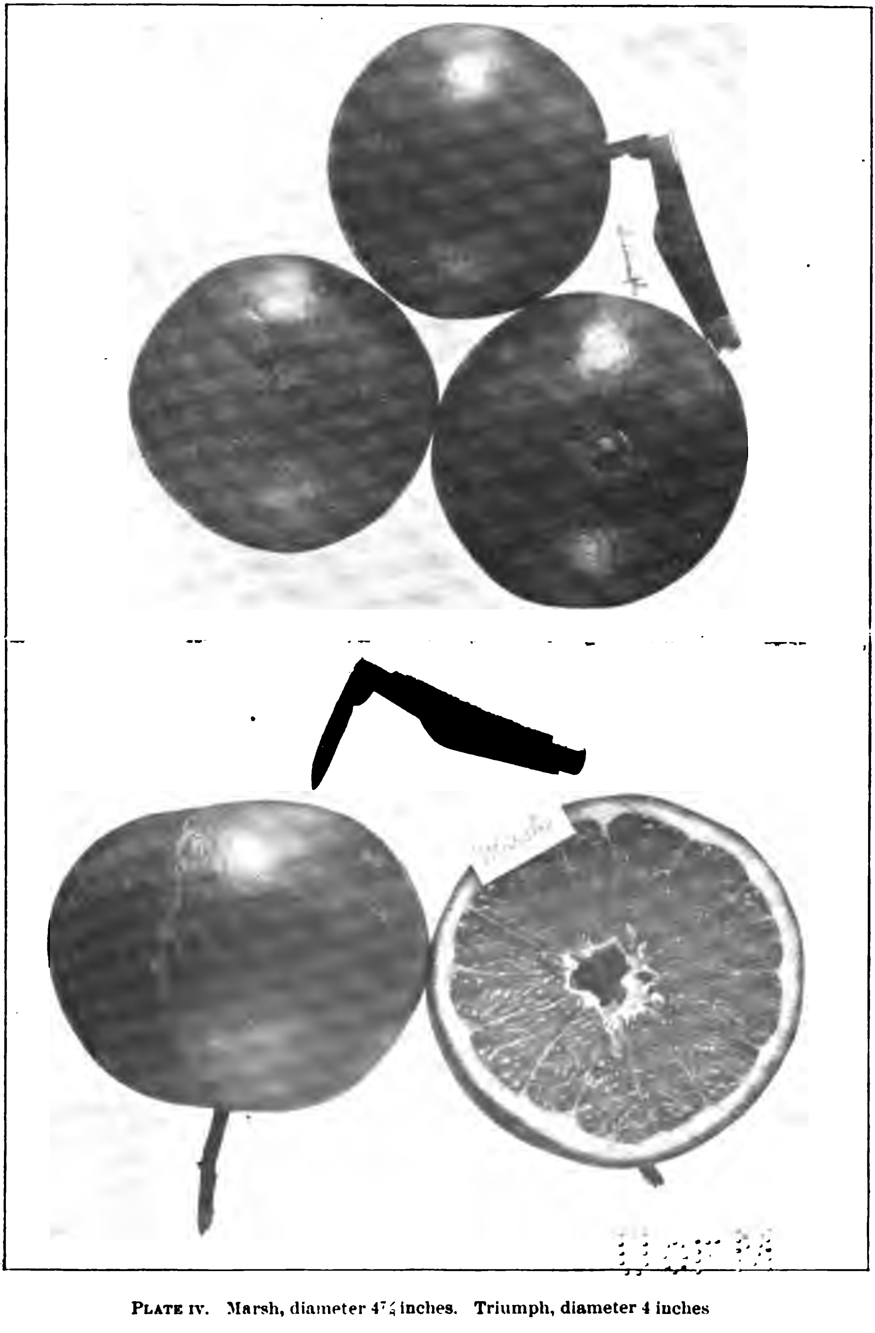

Plate IV. Marsh, diameter 4$\frac{7}{8}$ inches. Triumph, diameter 4 inches

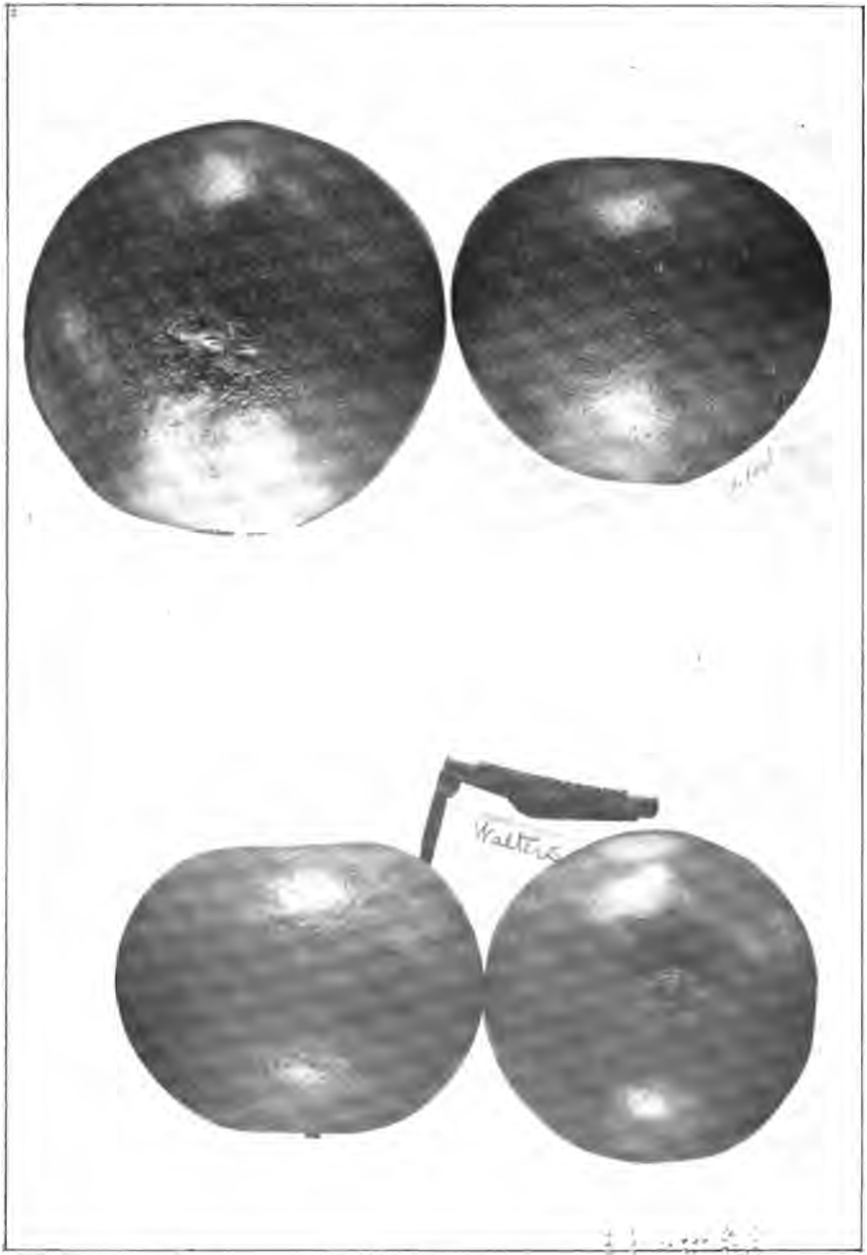

Plate v. McKinley, diameter 4¾ inches. Walters, diameter 4⅞ inches.

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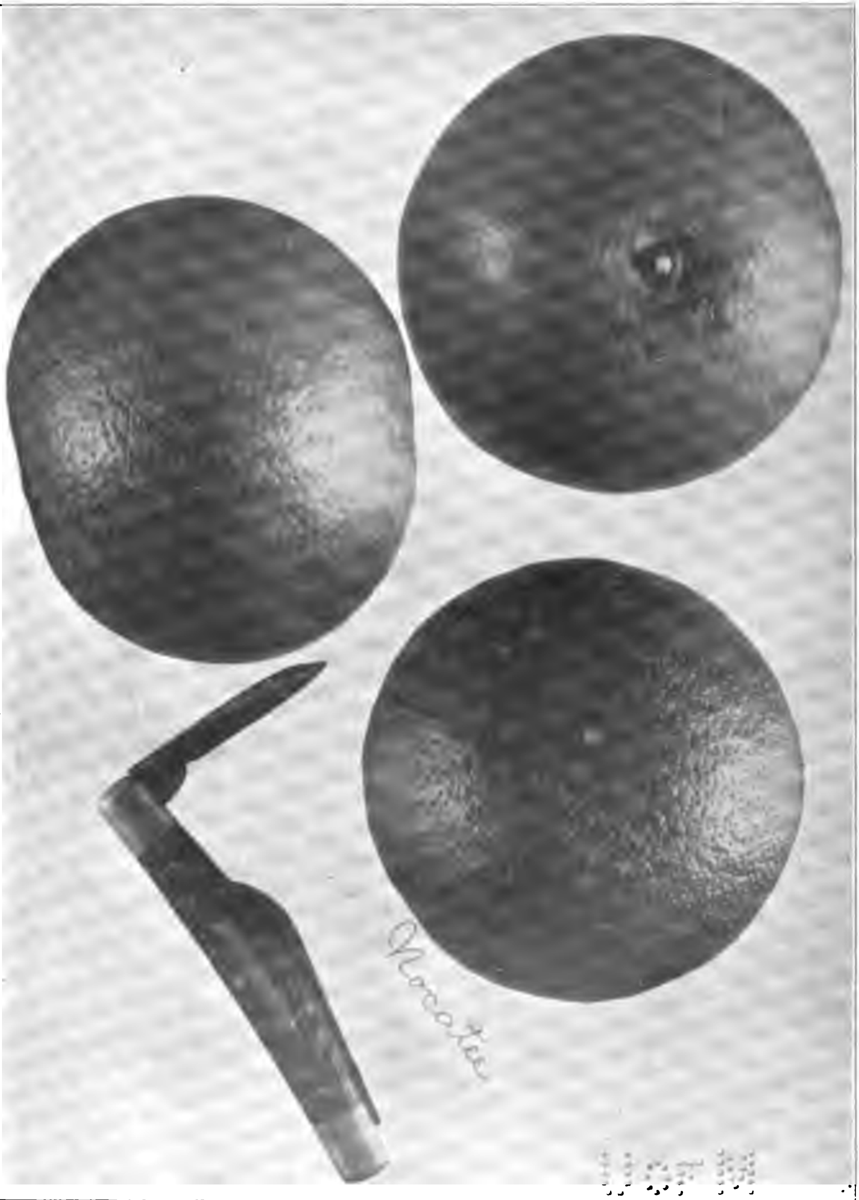


PLATE VI. Nocatee, diameter 2½ inches

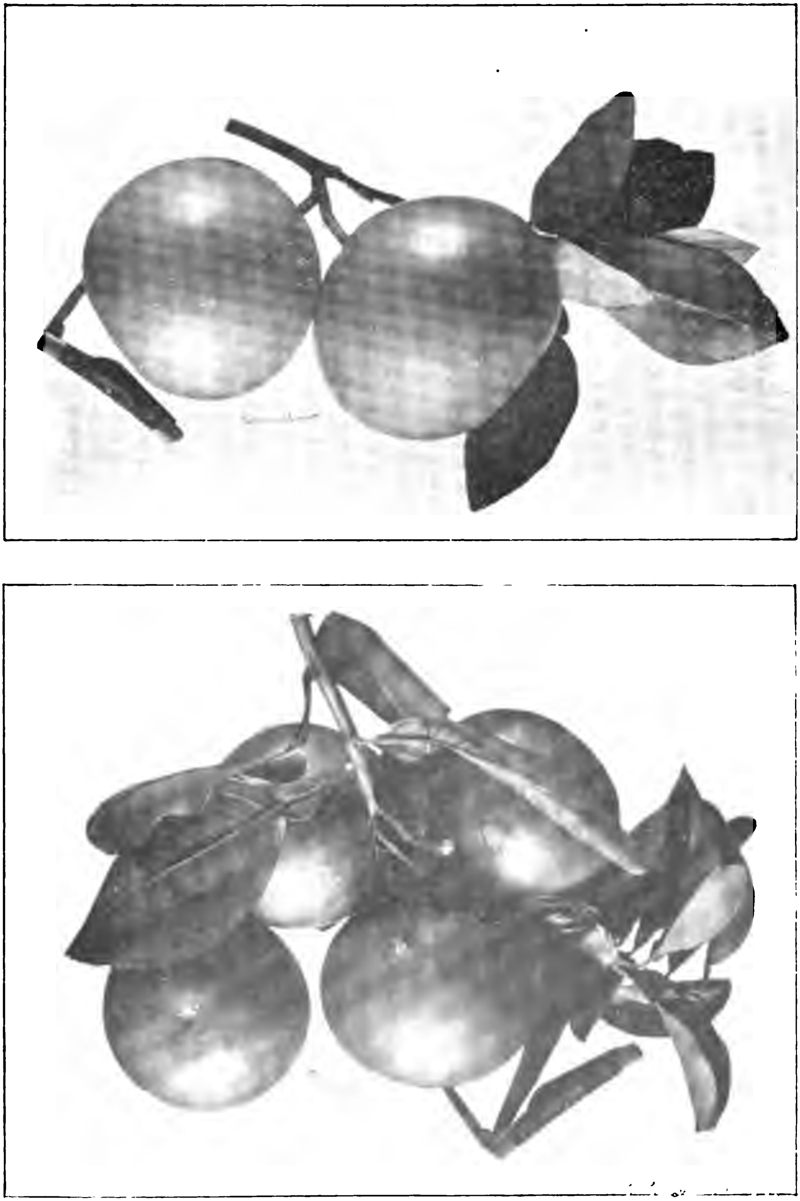
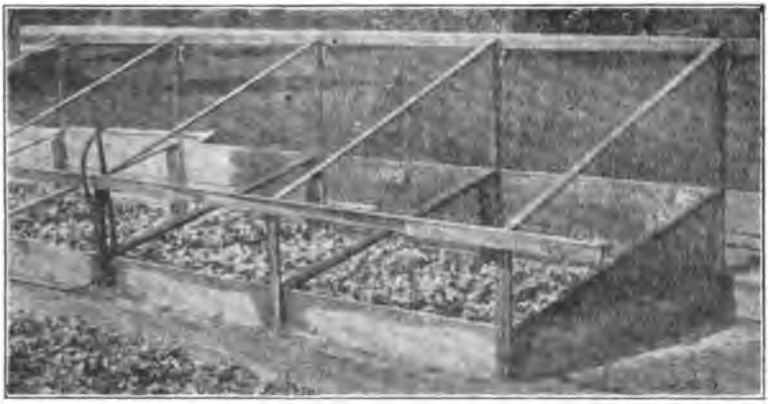


PLATE VII. Pernambuco, diameter 4¾ inches. Royal, diameter 3⅝ inches.

BULLETIN NO. 59. OCTOBER 1901.

FLORIDA AGRICULTURAL EXPERIMENT STATION.

CAULIFLOWER.



By H. HAROLD HUME.

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1902.

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CAULIFLOWER

GENERAL REMARKS.

From the experience of the past two years with cauliflower as a winter truck crop, on the horticultural grounds, the conclusion has been reached that it can be raised very successfully and with good profit. It is believed that when given the same care as lettuce, celery, cucumbers, or any other of our standard truck crops it will yield as large a return for the investment. In this crop we have a valuable addition to our list of remunerative truck crops both because it can be profitably grown and because it will help in diversifying garden work. For these reasons it has been deemed advisable to issue a short bulletin giving full cultural directions. The cauliflower is grown in a small way in our State and in the South, but at present most of the product which finds its way into the northern markets during the winter comes from forcing houses or in early winter from field grown plants which have been developed under cover after removal from the field. However, the crop cannot be held long, hence the supply is usually exhausted early in the season, and it is probably true that there is no surer market for any of our truck crops than there is for the cauliflower. It will bring a good price, provided, of course, that a high quality of product is shipped.

The crop is particularly recommended to those sections where cabbage has been successfully grown. Certain districts in Florida have won an enviable reputation for particular truck crops. The cauliflower is recommended to those sections where cabbage and celery have been successfully grown, but any district having good garden soil need not hesitate to undertake the crop.

CULTURAL.

Varieties:—Florida conditions call for a cauliflower of the forcing type, a vigorous, rapid-growing, sure-heading variety. The time required to reach maturity is of very considerable importance and when everything is taken into account, the dwarf varieties are the only ones to be recommended. The most satisfactory varieties, so far as our experience goes, are the Extra Dwarf Erfurt, Early Snowball and Dry Weather. The last named variety has given particularly good results on the Station grounds and appears to be well adapted to our rather exacting conditions. It withstands drought well and forms large heads of excellent quality.

Seed:—No more important element enters into the success of the cauliflower crop than the quality of the seed and to the seed alone is often due the difference between success and failure, profit and loss. The best seed that can be secured is the cheapest at any reasonable price, and it should always be obtained from a well-known, reputable seedsman. The standing of the seedsman is the only guarantee the trucker has that the seed is true to name and selected from the best strain. Aside from the remarks above, the variety does not count for so much as does the care exercised in selecting the seed of that variety. The cauliflower is very prone to deteriorate and unless the most scrupulous care is taken in selecting the seed, the variety will degenerate rapidly. Cauliflower seed is grown to some extent in

America, but most of the seed comes from Denmark, Germany and Holland and the best from the first named country (Denmark). The price of good seed is from three to five dollars per ounce and an ounce of seed will generally give about fifteen hundred plants suitable for the field. If an ounce of seed will give about fifteen hundred plants and if they are set in the field as recommended; namely, 2x3 ft., 7260 plants will be required, or between four and five ounces for an acre.

The seed should be purchased some time before required for planting and tested as recommended in Press Bulletin No. 3. In this way the percentage germination may be ascertained and more seed ordered if necessary. The time required for germination is from five to ten days, depending upon the amount of moisture, heat and the quality of the seed. Generally speaking, those seeds which germinate first will give the best plants, as, in well ripened seed, early germination denotes a vigorous constitution. But, if the seed is of first-class quality, practically all the plants will break through the soil at the same time.

Seed-bed:—The seed-bed should be carefully prepared. We prefer to use virgin hammock soil. This should be enriched with a liberal application of commercial fertilizer, or thoroughly decomposed stable manure. After the fertilizer is applied it should be thoroughly worked in to a depth of three or four inches. From a few days to two weeks should elapse before the seed is sown for there is great danger in planting seed too soon after applying commercial fertilizer as the seed is likely to be destroyed by the action of the mineral substance unless it has been dissolved and thoroughly incorporated with the soil. The time between the application of the fertilizer and the sowing of the seed will depend upon the amount of rainfall and it is often better to wet down the seed-bed each day for four or five days before planting and not to depend upon the uncertain rainfall.

On the horticultural grounds the seed-bed used is a portion of an ordinary cold frame, one foot high at the front, three feet at the back, six feet wide, forty feet long and placed so as to face slightly southeast; during warm weather this is kept shaded during the middle of the day with a cotton cover placed about three feet above the frame. (See frontispiece.)

Seed-Planting:—The earliest date at which we have succeeded in getting a good stand of plants is the first week in August. Attempts at an earlier date have usually been unsuccessful on account of the warm weather, which prevails at that season.

The soil should be *freshly opened just before sowing*, the seeds placed in the soil while it is still moist and covered immediately. This applies to the planting of all kinds of seed. It is best to sow the seed by hand. Open the drill a half inch deep with a pointed stick, scatter the seed thinly along, replace the soil and gently tamp it down. The rows should be about three inches apart. In six or seven days the young plants should begin to appear and the ground between the drills should be cultivated. Do not allow the soil to dry out as the cauliflower plant from seed to head should never be checked. Neither should the bed be kept too wet, else there is danger of "damping off." The happy medium must be sought. The bed should be carefully watched and if the disease does break out it may be checked by removing the diseased plants, working the soil, scattering dry sand and sulphur along the rows and withholding water until the surface soil becomes dry.

It might be pointed out here that about six months must be allowed from the sowing of the seed until the crop matures.

Transplanting in Seed-bed:—The plants should not be allowed to remain long in the seed rows. If left too long they will soon crowd and become weak and spindling. When they have reached the height of one inch, they should be pricked off and set in another portion of the bed. They may be set in rows four inches apart with the plants one and a half to two inches apart in the rows. Here they should remain until ready for the field. If care has been exercised all the way through, the plants will be short, stocky and vigorous. By the time they are four or five inches high or when the leaves have lapped they are ready for the field. It is not best to let them get too large, because there is often a delay of a few days in order to obtain good climatic conditions for setting out. If left too long in the seed bed, greater care must be exercised in transplanting, else the plants may suffer a severe check and will button or break irregularly instead of forming smooth well-shaped heads.

Soils and Preparation.—Soil which will produce good cabbage will be found to be well adapted to the cauliflower but cauliflower should not be grown after cabbage on the same ground. The soil should be rich, well supplied with organic matter and moist, though well drained. If the field can be irrigated, the success of the crop will be assured.

Work should be started on the ground at least a month before the plants are set out. The cauliflower is a deep rooted plant, consequently the soil should be prepared deeply. It is not advisable to turn under the good surface soil and to obviate this ground may be plowed shallow and then stirred and opened with a bull-tongue to a depth of seven or eight inches. After this the surface should be cultivated to a depth of two or three inches. Give thorough preparation by frequent cultivation before the fertilizer is applied, preparatory to setting out the plants.

Setting Out.—It is best that the plants be set out either just before or immediately after a rain, but if this cannot be done they should be set out late in the evening and watered, giving each plant about a quart of water. A cloudy day is much preferable to a clear one and if the day on which the plants are set out is followed by cloudy weather so much the better.

The ground should be leveled or smoothed over, for which purpose a roller or float may be used. After this the ground may be marked off. Two markers should be constructed, one with the teeth three feet apart, the other with the teeth two feet apart. These may be made of wood after the pattern of an ordinary garden rake. In place of a marker a line may be used or the ground may be checked off with a light hand plow.

Only a limited number of plants should be removed from the seed-bed at one time. The leaves should be cut back about one-half or one-third, using for the purpose a large pair of shears. Sprinkle the plants with water as soon as removed from the bed, place in a shallow box or basket and keep them shaded from the sun. Two men and a boy can do the work more economically than two persons can without the third assistant. The boy should drop the plants at the checks, just as they are needed and the men do the planting. The plants should be set deep. Use a dibber. With the instrument in one hand open a hole deep enough for the plant. With the other hand pick the plant up, place it in the hole and with both hands press the earth firmly about it. After planting the plants should be watered, unless the soil is already quite moist and a little dry earth should be thrown over the moisture to act as a mulch.

Fertilizers and Fertilizing:—The cauliflower is a gross feeder and requires large amounts of fertilizer. In short, for the successful growing of this crop the ground can scarcely be made too rich and fertilizer must be applied with a liberal hand.

The analysis of the cauliflower shows that it contains .13 per cent. nitrogen, .16 per cent. phosphoric acid and .36 per cent. potash. To plant an acre setting the plants as recommended, namely, 2 x 3, 7260 plants will be required. The total weight of the crop, granting that each plant, root, stem, leaves and head will weigh six pounds, would be 43,560 pounds. Such a crop would remove from the soil 56.62 pounds of nitrogen, 79.69 pounds of phosphoric acid and 156.81 pounds of potash.

The amounts actually found in the plant would be too little to apply, for a certain quantity is always lost to the plant or cannot be taken up by the crop on the ground, and no plant is capable of taking up every particle of fertilizer that is applied. Hence the fertilizer must be given in larger amounts than is actually required by the crop. The materials used in our work at the Station have been stable manure, nitrate of soda, cotton seed meal, acid phosphate and high grade sulphate of potash. The stable manure, thoroughly decomposed, together with one-half the commercial fertilizer is applied broad-cast from two to three weeks before planting the crop and worked into the soil.

Of the materials mentioned above there are required 250 pounds of nitrate of soda, and 400 pounds of cotton-seed meal, 600 pounds acid phosphate and 400 pounds high grade sulphate of potash. Sufficient stable manure is used to cover the ground one inch or an inch and a half deep. If the soil is very rich in humus the stable manure may be omitted, in which case the amount of fertilizer should be slightly increased.

The amounts as given above are sufficient for any ordinary soil, at all suited to the culture of the vegetable, but no one can determine how much is needed on any given field, except the planter himself. Many soils will require less and others might require more but it should be remembered that the amount applied bears a direct relation to profit. An attempt might be made to grow the crop on a field which required so much fertilizer as to reduce the margin between the cost and selling price below the profit line.

As already indicated one-half of the commercial fertilizer may be applied before planting; if so, the remainder should be given a month and a half or two months after the crop has been set out. However, it is preferable that the nitrate of soda be applied in several separate dressings. It is frequently an excellent plan to compost the acid phosphate, potash and cotton-seed meal with the stable manure and apply it all before the crop is set out.

If the fertilizer is divided, the first application may be given along the rows in which the plants are to stand, or it may be applied broad-cast. The latter is the better plan, but in either case the ground should be cultivated immediately afterward. That portion of the fertilizer which is applied after the plants are set out and started off should be scattered around them and the ground cultivated or raked.

Cultivation and Care:—The field should be frequently cultivated and the ground should be scarified at least every week and after every rainfall. The best tool for cultivating is an ordinary cultivator and the ground should not be worked to a greater depth than two and one-half or three inches. This will preserve a surface mulch of dry earth and prevent loss of moisture by evaporation.

As soon as the heads commence to form the leaves should be drawn together at the top and loosely tied near their tips with a piece of cord or twine. Rafia makes a good substitute for twine and is preferable because there is less danger of cutting the leaves. We have tried the practice of breaking down the leaves over the head but have found that it is not quite so satisfactory. If the heads are left uncovered they become yellow through the action of the sun and rain but when the leaves are drawn together and tied, they bleach out pure white, and curd-like.

Insects:*—Three or four insects trouble the cauliflower as well as the cabbage and among these may be mentioned cut worms and cabbage worms. Of the latter there are at least four distinct species to be found feeding on the crop in Florida, these are *Plusia brassicae Pieris rapae, Pieris protodice* and *Plutella macullicollis.*

The cut worms may be controlled by using poisoned bait. We have found that bran, molasses and Paris green makes an excellent mixture for this purpose. Sufficent Paris green should be mixed with the bran to give it a greenish tinge and to this should be added enough molasses or syrup to make it sticky. This poisoned bran may then be scattered in a small circle about each plant. It is an excellent plan to scatter poisoned leaves of cabbage, beggar-weed or velvet beans over the field a few days before planting but we have generally used the first mentioned plan and find it quite efficacious.

---

*For the notes on insects I am largely indebted to Prof. H. A. Gossard, Station Entomologist.

Any of the above named cabbage worms can be controlled by using Paris green or arsenate of lead. These poisons can be applied to the young plants before they commence to head with perfect safety to the consumer. There is considerable difficulty in using Paris green in solution as the mixture will not stick to the plants. This can be overcome by using dissolved soap in the solution, one pound of hard soap to forty gallons of mixture. The arsenate of lead should be used in the proportion of three or four ounces to forty gallons of water and Paris green in the same proportion. With Paris green a certain amount of milk of lime should always be used to prevent scorching of the foliage. Paris green may be put on the plants in the form of a powder by mixing it with flour. One pound of Paris green to forty pounds of flour makes a powder of good strength. This should be dusted over the plants while the dew is on them. The flour mixture may produce burning if too freely used, so some prefer to mix with lime, a leveled teaspoonful of Paris green being used with a quart of lime and applied by dusting in exactly the same way as with the flour mixture. Arsenate of lead may be prepared as follows: Take 11 ounces of acetate of lead and 4 ounces of arsenate of soda and dissolve together in two or three gallons of water. This should be diluted to 100 gallons for immediate use. The same amount of poison can be used in 50 or even 10 gallons of water without danger of injury to the plants. Arsenate of lead already prepared may be procured of Wm. H. Swift & Co., Boston, Mass.

MARKETING.

Gathering.—Cauliflower may be cut before it is mature but the flavor is not so well developed as it is when the heads are full grown. For winter shipment heads from four to six inches in diameter are of a desirable size and the market will take them fully as well or better than large ones.

The field should be picked over at least every two or three days during the season, though heads will remain in good condition for nearly a week if the weather be cold. Examine the head by separating the leaves on the side. As soon as the head is well rounded up in the center and developed so as to force the leaves outward, and assumes a grained appearance, it will be found to be fully matured.

The heads should be cut, preferably, when dry. If moist they are likely to decay in transit. The best time of day is the afternoon if they are intended for long distance shipment. About an inch of stem should be left on the head and three rows of leaves. After cutting, the heads should be carfeully placed in a wagon and carried to the packing house or on dry pleasant days packing may be done in the field.

Packing.—The package recommended for general use is the ordinary lettuce basket. Before packing, the leaves should be cut back to stubs, leaving them somewhat longer than shown in the illustrations. Each head should be carefully wrapt in a large sheet of white glazed paper. The baskets should be packed snug and tight without bruising the heads, and only those of uniform size should be placed in each basket. Never place different sizes in the same package and always discard inferior or injured heads; the compost heap is the place for them.

H. Harold Hume.

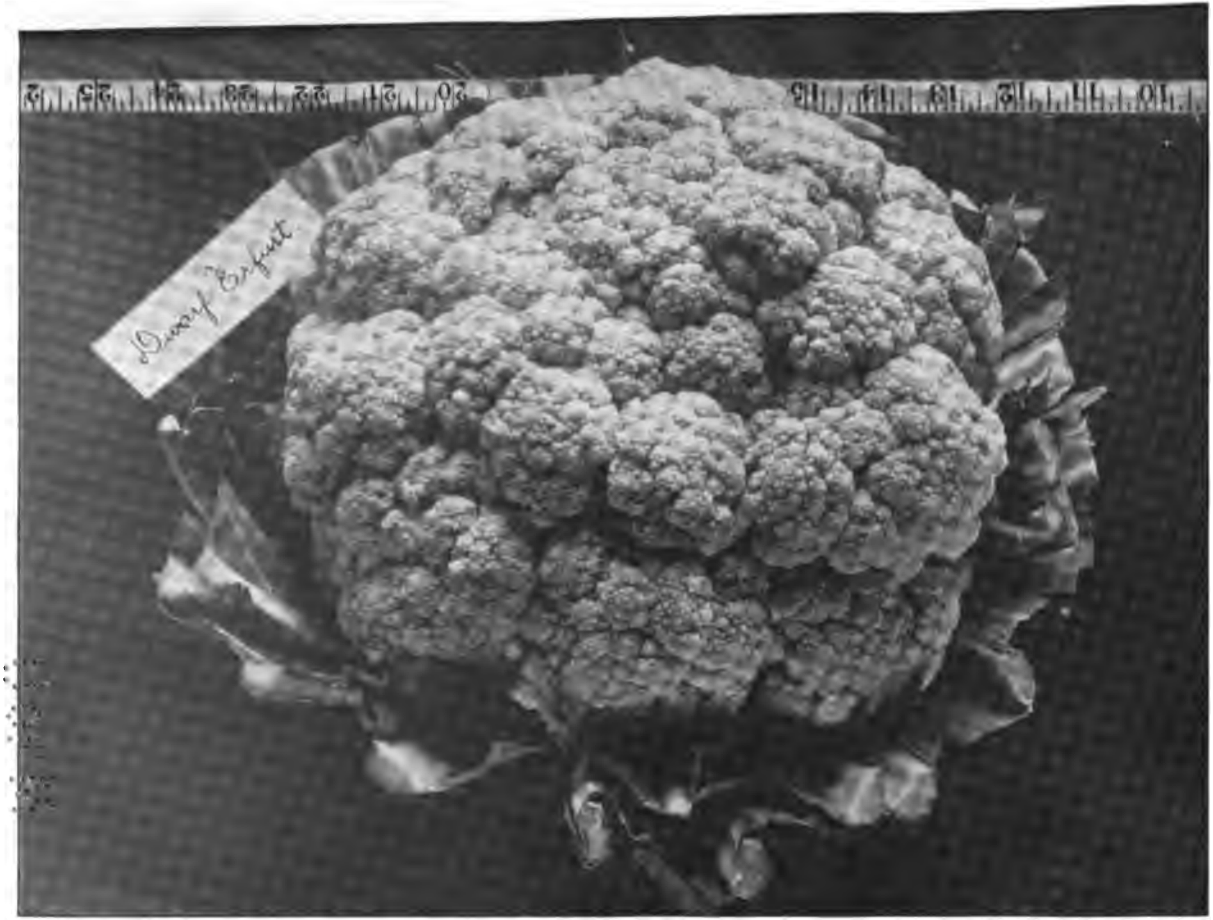

PLATE I.—HEAD OF DWARF ERFURT CAULIFLOWER.

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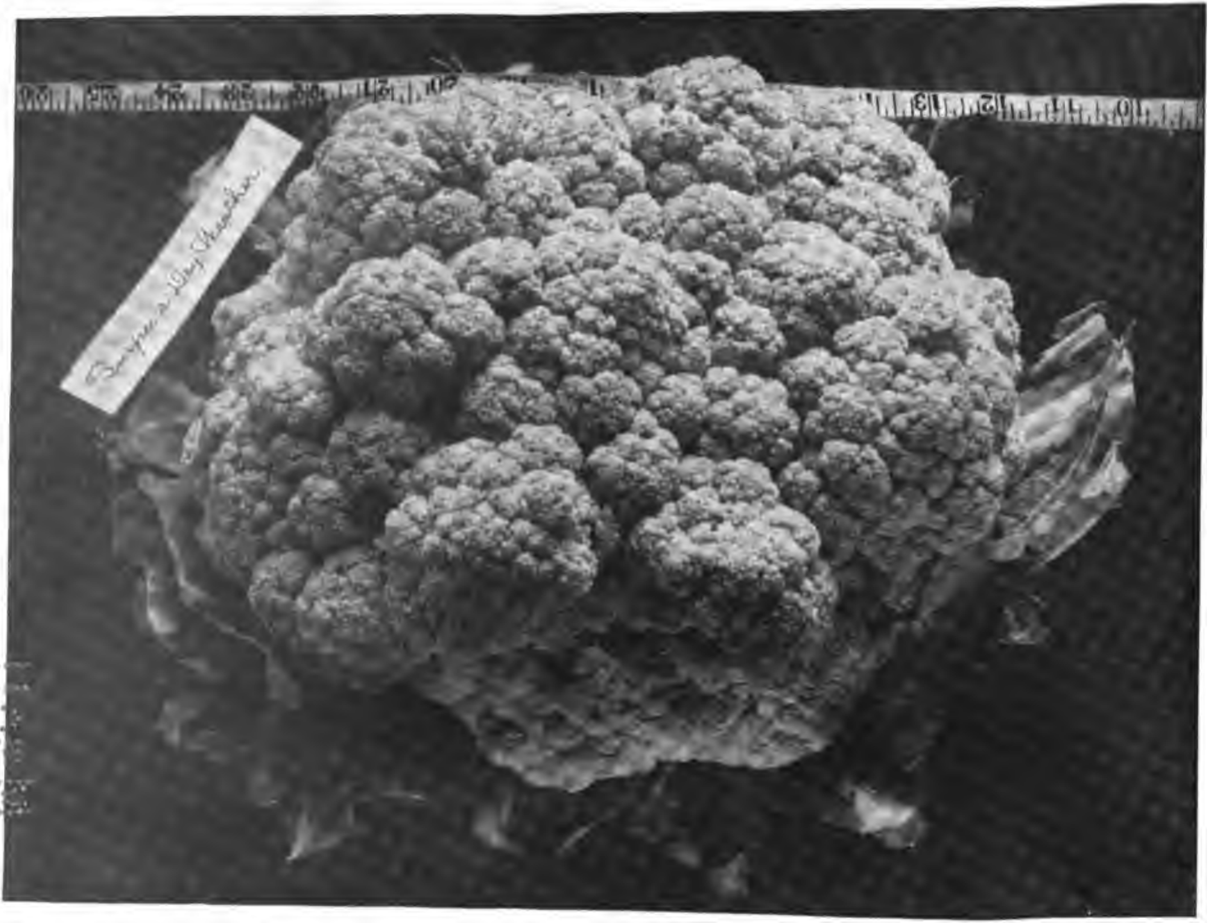

PLATE II.—HEAD OF DRY WEATHER CAULIFLOWER.

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BULLETIN NO. 60. JANUARY 1902.

FLORIDA
AGRICULTURAL EXPERIMENT STATION.

VELVET BEAN.

By H. K. MILLER.

The bulletins of this Station will be sent free to any address in Florida upon application to the Director of the Experiment Station, Lake City, Fla.

DeLand, Fla..
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1902.

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H. K. Miller, M. S.	Chemist.
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INTRODUCTION.

It is well known that a very large portion of the money received by the farmers of Florida, from the sale of their staple crops, is sent out to the states north and west of us for hay. cattle foods, meat products, and nitrogenous fertilizers. The market prices of the staple crops produced in Florida for a number of years past have been so low that those engaged in producing them have been forced to exercise rigid economy along certain lines in order to keep their expenses within their income. As a result many, and I may say the majority, of those producing cotton, corn, and tobacco are relatively in a much poorer financial condition than the farmers of the west, who give their time to growing wheat, corn and hay. This condition has, to a large extent, been brought about through the practice acquired by our farmers of spending their cash for those products above mentioned. This has contributed to the prosperity of the western farmers as well as to the poverty of the Florida farmers, for the things purchased can, for the most part, be more economically produced in this state than elsewhere, to say nothing of the additional cost of transportation, which alone is an enormous tax on our resources as well as those of the entire south. It has been conclusively demonstrated that foods for cattle can be more abundantly produced in Florida in greater variety and at less expense than in the states from which we have been purchasing these supplies for a quarter of a century. This being true it stands to reason that meat, from both swine and cattle, may be produced at home with less labor and smaller outlay than in the west where the severe winter weather must be provided against.

The farmers of this state are in a position to be the most independent of any in our country. The excellent condition of a few of our farmers attests the correctness of this statement so that it is not mere theory but a demonstrated fact. Another burden which has weighed heavily upon our farmers has been the injudicious expenditure of their money for commercial fertilizers. The most expensive constituent of these fertilizers is nitrogen, and the necessity of those engaged in general farming for purchasing this costly element does not exist. This nitrogen costs from twelve to eighteen cents a pound while potash and phosphoric acid cost only about five cents a pound. For every pound of nitrogen eliminated from a fertilizer three pounds of potash or phosphoric acid may be substituted without altering the cost. Every farmer in Florida has it in his power to make this substitution and to produce all the nitrogen at home which his farm requires at little or no expense. This may be accomplished by growing some of the leguminous crops such as melilotus, clover, winter and hairy vetches, alfalfa, beggar-weed, cowpeas, and velvet beans. Those best adapted to our needs are cow-peas, hairy vetch, beggar-weed and velvet beans. It is reassuring to notice that many of our farmers are becoming interested in the merits of these plants and are beginning to take advantage of them for restoring the fertility of their farms.

If our farmers are to better their condition they must combine brains with their labor and take advantage of everything which nature furnishes so that they may diminish the outgo and increase the income. A great many letters are received at the Station asking for information regarding the velvet bean, and sinc this plant is one of the many which will help the Florida farmer to become more prosperous, it has been throught well to make it the subject of this bulletin.

THE VELVET BEAN.

While this plant has been known in the State for more than twenty-five years it received little attention prior to 1895. Until this time it had been used in Florida to a limited extent as an ornamental vine. The attention of this Station was directed to the plant in 1895 by Mr. W. P. Newheart, of Ocoee, who stated that it had been used in his neighborhood about twenty years as a covering for trellises and unsightly places. He was so impressed by the enormous growth the plant made that he decided to try it in his orange grove as a soil renovator and was very much pleased with the results. (Bulletin 35, page 343 Florida Experiment Station.)

A short article was written on the plant, after growing one crop at the Station, by Dr. O. Clute and published in Bulletin No. 35.

Since its introduction at the Station in 1896 it has been planted each succeeding year and a number of field and laboratory experiments have been conducted in connection with it. In the meantime knowledge of it has become quite general in Florida and at present many farmers in the state make use of it.

The following description of the plant has been furnished me by Mr. H. Harold Hume, of the Station Staff.

Mucuna utilis (*Wallich*) *Velvet Bean.*—A twining vine frequently upwards of 75 feet in length, stem branching, smooth and rather slender. Leaves trifoliate, leaflets rombic-ovate or broadly ovate, acute at the apex, rounded at the base, 4 inches long, 2 1-2 inches wide. Lateral ones inequilateral, pedicle 4 inches in length, stipules and stiples inconspicuous; inflorescence axillary racemose, drooping, frequently a foot or more in length; flowers in groups of three at a point, groups arranged spirally, three to thirty flowers in the raceme; pedicles short, calyx greenish, changing to gray in

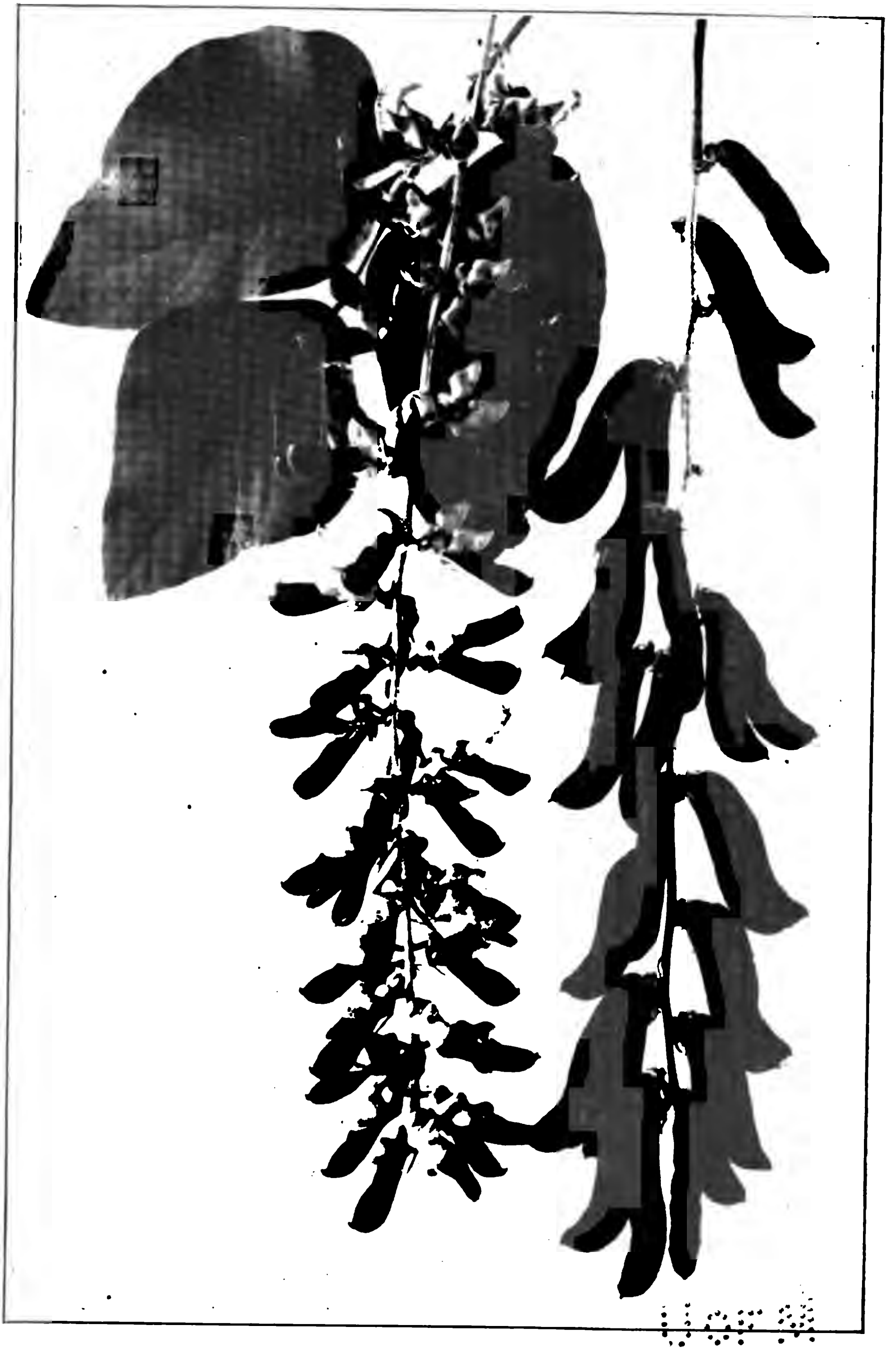

FIG. II.

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fruit, corolla deep purple, standard short and blunt, wings about twice as long as the standard, narrow and blunt, keel whitish purple, closely surrounding the stamens; Legumes 3 inches long, 5-16 inch thick, 5-8 inch wide, falcate, roundish and constricted slightly between the seeds, blunt covered with a dark velvety pubescence, whence the common name; seeds 9-16 to 5-8 of an inch in length, 5-16 inch thick, 7-16 inch wide, rather oblong in outline, markèd and spotted with brown and dirty white, hilum about 1-4 inch in length, elevated and distinctly marked. The plant is a native of India, introduced into America by the United States Department of Agriculture about twenty-five or thirty years ago.

Nodules 1-8 to 1 1-4 inches in diameter, brownish black, tuberculate broad, flat, about 1-8 to 1-4 inch in thickness, interior greenish or pinkish green.

VELVET BEAN CULTURE.

The velvet bean requires a long season in order to mature the seed; therefore, its cultivation will be confined to sections where the growing period is fully eight months. It will do well and mature the seed in Florida and the southern part of the Gulf States. The plant grows well as far north as Tennessee, but beyond southern Georgia it is necessary to purchase seed each year for planting.

In Florida the planting should be done in March or April. The quantity of seed to be used for planting an acre may be varied from one to two bushels. The planting may be broadcast yet it is better to plant in rows about four feet apart leaving a space of from one to two feet in the row. This admits of cultivation until the plants are well established and aids in freeing the land from objectionable weeds and grass. and so the resulting forage will be much better than otherwise. After the velvet bean obtains possession of the soil it shades the ground so completely that other plants are ical illustrations of these nodules. No. III is from a photograph of a root of the velvet bean that was carefully removed from the soil so as not to break off the nodules. No. IV is from a photograph showing the actual size of some of these nodules. These nodules are found on the same plant in various stages of development from the size of a bird shot to that of the one shown in the illustration.

The roots and stubble contain a considerable portion of the nitrogen obtained from the air and as they are left in the soil decomposition gradually takes place and the nitrogen thus becomes converted into a form that is available to those plants which do not have the power of obtaining a supply directly from the atmosphere. The whole of the nitrogen obtained from the air by a crop of velvet beans is by no means left in the roots but the greater portion of it is stored up in the leaves, vine, and seed, though the soil gains much of this from the leaves which are shed by the plant. If so desired the entire plant may be left to decay on the surface and turned under the following spring, but, it is not advisable to turn under the green vine as it will cause the land to become sour and this will have to be corrected by an application of lime. It is not even profitable to let the plant die down on the surface and subsequently turn it under, inasmuch as the hay which may be made from the vine is much more valuable as a food than the vine is worth as a fertilizer. Besides, if properly managed the fertilizing constituents of the hay may, to a large extent, be saved in the form of manure. In order to form an estimate of the quantity of nitrogen which may be procured from the air through the use of the velvet bean, the root from a vine was carefully removed from the soil, dried, weighed and analyzed. The results were then calculated to the basis of one acre. It was found that on one acre six hundred and ninety pounds of dried root would be produced. This root contained 1.41 per cent of nitrogen, so from the

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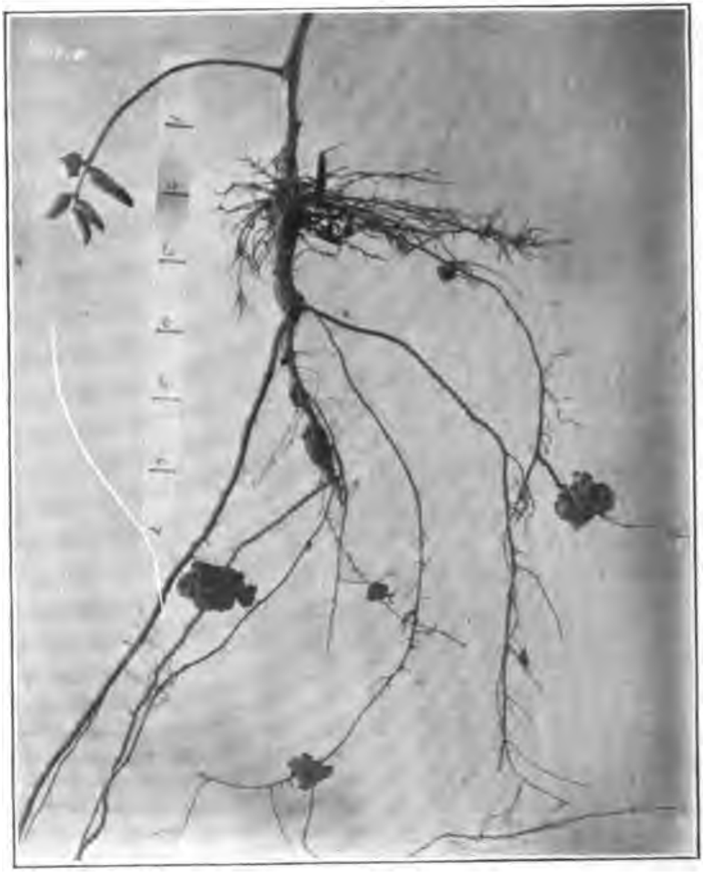

FIG. III.

root alone 9.7 pounds of nitrogen would be added to an acre of ground.

This could not be considered a fair index to the weight of nitrogen added, in as much as, most of the nodules had already decomposed when the root was collected and the nitrogen from these is not included in the estimate. The quantity of nitrogen was also estimated which was removed in the hay from an acre.

Weight of green vine on an acre	21132	pounds.
Weight of dry hay	5953	pounds.
Percentage of nitrogen in hay	2.21	
Weight of nitrogen in hay	131.5	pounds.

In this way it is shown that a crop of velvet beans on one acre, after yielding three tons of hay, supplies 9.7 pounds of nitrogen to the soil, a quantity which is usually sufficient for the following crop. If on the other hand the hay is turned under after drying, an acre of land would have its nitrogen increased by 141.2 pounds. It would then be unnecessary to add nitrogen to land so treated for several years. The entire amount of nitrogen saved in this manner represents a cash value of from fifteen to eighteen dollars. Similar investigations have been carried out by Dr. W. C. Stubbs and C. E. Moores at the Louisiana Station; also by J. F. Duggar and Dr. J. T. Anderson of the Alabama Station. The results obtained in the three different states are given here in tabular form, and while considerable variations exist this is to be somewhat expected since the conditions must have been very different. These results show very conclusively that the velvet bean is a valuable plant for restoring nitrogen and humus to our impoverished soils.

	ALA.	LA.	FLA.
Weight of green material from an acre	19040	22919	21132
Weight of dried material from an acre	8240	7495	5953
Weight of dried roots from an acre	1258	191	690
Weight of nitrogen in vines from an acre	201.3	170	131.5
Weight of nitrogen in roots from an acre	12.6	2.9	9.7
Total nitrogen in crop from one acre	213.9	172 9	141.2

A most striking example of how the soil may be renovated through the use of the velvet bean is seen from the results of a field experiment made by J. F. Duggar at the Alabama Station. Oats were planted on a plot following velvet bean stubble, on a plot following velvet bean turned under, and on a plot following crab grass hay. Only potash and phoshoric acid were used as fertilizer. The cultivation and fertilizing of the plot, being alike in each case. As a result the plot on which the vines were turned under yielded oats at the rate of twenty-eight bushels an acre, that on which the oats followed the velvet bean stubble yielded at the rate of thirty-eight bushels an acre, while the plot on which the oats followed the crab grass yielded only seven bushels per acre. (See Bulletin No. 95 Alabama Experiment Station).

Two facts are brought out by this experiment: first, it is better to utilize the velvet bean as hay than to turn it under for fertilizer; second, by following velvet bean with oats more than five times as much grain was produced with the same outlay of labor and fertilizer. One objection to this method of soil improvement is that it requires two years to produce the desired crop, yet it will prove much more profitable to raise a crop of hay one year, which is worth far more than the cost of making it, and then obtain a heavy yield of grain one season than get small returns two years or else resort to purchasing nitrogen. It will pay to give up a part of the farm to velvet bean each year and by proper rotation build up the soil to a high state of productiveness. It must be remembered that the velvet bean supplies nitrogen only, and if the land is deficient in the other plant foods these must be supplied from artificial sources.

VELVET BEAN AS FORAGE.

Attention has been called to the fact that velvet bean hay contains a large quantity of nitrogen for which it is valuable for restoring this element to the soil, though, as before stated, it is not economical to turn the crop under for this purpose. The percentage of nitrogen multiplied by 6. 25 gives the percentage of crude protein in the hay. The feeding value of the hay then is much greater than its fertilizing value, besides a very large portion of the fertilizing elements may be saved as manure, while the hay at the same time may be converted into meat, milk, and butter. In this way two values are utilized, while if the hay is turned under only the lesser value is turned to profitable account.

In making use of the velvet bean as a food for animals three methods may be followed: the vine may be fed green or the field converted into a pasture; the vine may be converted into hay and saved for winter feeding; the beans may be gathered and.prepared for use as a concentrated food. In making use of velvet beans as food care should be exercised not to start an animal on a full feed either of the green vine or the bean meal, as the result may prove injurious and possibly fatal. The value of a food depends to a great extent on its compositon though it is not possible to arrive at this value by an analysis alone. We must know not only the constituents in the food but must also know the digestive coefficients of these constituents. Food is for the purpose of building up waste tissues, that is, for the production of flesh, muscle, blood, nerves, etc., and for supplying energy and heat.

In a food there are two classes of compounds which are important, the proteids, or albuminoids, which tend to produce flesh, muscle, blood, nerve, etc., and the carbohydrates, which produce heat, fat and energy. Most foods also contain fats which like the carbohydrates are heat producing substances though one pound of fat is equivalent to about two and one-fourth pounds of carbohydrates. The carbohydrates consist of the sugars, starch, fiber, etc., while the proteids are nitrogenous compounds, the most expensive constituents of a food. While it is possible for the carbohydrates to supply only fat, energy, and heat, protein will supply both flesh and energy, yet to convert protein into energy or fat is not economical as these may be obtained at much lower cost from the much less costly carbohydrates. For the best and most economical results the quantity of digestible protein should bear a certain ratio to the digestible fat or heat forming constituents in a ration. This ratio varies within certain limits, depending upon the kind of animal and the character of work the animal is engaged in, though in general the ratio should be about one of protein to six of heat or fat producing constituents. In order to find the digestive coefficients of the different constituents of a food it is necessary to feed an animal a weighed amount of the food in question (the composition of which has been determined by analysis), to collect all the excrement from this, weigh it and determine its composition. The difference between the amount of any constituent fed and the amount excreted represents the amount digested by the animal. The amount digested divided by the amount fed gives the digestible coefficient of that constituent in the food under consideration.

An experiment of this nature was conducted by the Chemical Department of the Station to ascertain the nutritive ratio of green velvet bean vines. By nutritive ratio we mean the ratio of digestible flesh forming constituents to the digestible fat forming substances.

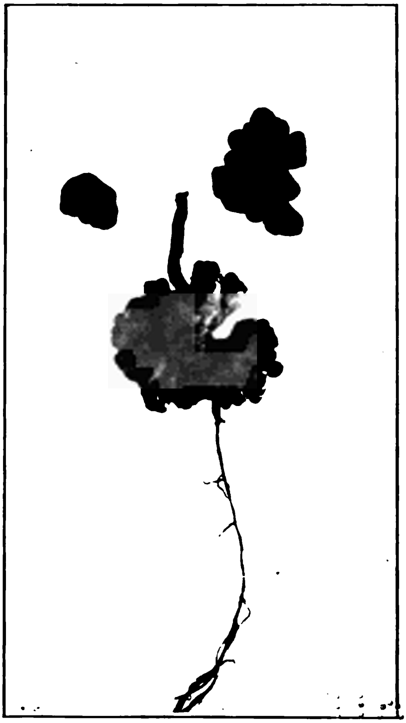

FIG. IV.

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Two healthy young steers were selected for the experiment. They were confined in stalls and were fed on the green vine seven days before the collections were begun, in order to allow the excrement from other food to pass out of the animals. The experiment was started October 29, 1900 and continued six days. The animals were fed three times daily, the vines being weighed for each animal. A small sample of the vine was selected each day, these were afterwards mixed and analyzed. All the waste vine was collected after each feeding, weighed and analyzed. In addition to this oil-cloth bags were secured to the animals in such a manner as to collect all the excrement, which was removed twice daily and weighed. All the material thus obtained was kept separate for each animal and prepared for analysis.

In the table below the results obtained from this experiment are given in condensed form:

TABLE NO. I. DIGESTION OF GREEN VELVET BEAN VINES; SHOWING THE WEIGHT IN OUNCES OF THE MATERIAL AND CONSTITUENTS FED, WASTED, AND EXCRETED, TOGETHER WITH THE PERCENTAGE OF EACH DIGESTED, AND THE NUTRITIVE RATIO.

STEER NO. I

	Total	Dry Matter	Protein	Fats	Fiber	Ash	Nitrogen free extract
Ounces fed	3568	935.5	138.8	22.1	302.2	58.5	413.9
Ounces wasted	548	177.4	18.0	3.4	71.9	9.6	74.5
Ounces consumed	3020	758.1	120.8	18.7	230.3	48.9	339.4
Ounces excreted	1152	250.9	31.6	4.2	96.1	52.5	66.5
Ounces digested	....	507.2	89.2	14.5	134.2	—3.6	272.9
Percentage digested	.. ..	66.9	73.8	77.5	58.2	.....	80.4

Nutritive ratio .... 1 : 5.3

STEER NO. 2.

	Total	Dry Matter	Protein	Fats	Fiber	Ash	Nitrogen free extract
Ounces fed	3232	817.4	125,7	20.0	273.7	53.0	375.0
Ounces wasted	416	134.0	13.7	2.5	54.3	7.3	56.2
Ounces consumed	2716	713.4	112,0	17.5	219.4	45.7	318.8
Ounces excreted	1208	201.6	30.5	2.6	85.7	32.8	50.0
Ounces digested	...	511.8	81.5	14.9	133.7	12.9	268.8
Percentage digested	...	71.6	72.8	85.1	60.9	28.2	84.3

Nutritive ratio .... 1 : 5.7

The results obtained with the two animals are fairly concordant, the nutritive ratio in one case being 1 :5.3, while in the other case 1 :5.7. If we accept the average of these results for the nutritive ratio of green velvet bean, the ratio will be that which is considered best for a horse at hard work or for fattening a steer during the middle period.

The ash constituents which are digested form the bone and mineral matter of the animal body, but this is not included in the calculations when finding the nutritive ratio. It will be noticed that with steer no. 1 more ash seems to have been excreted than consumed, this, however, is the result of being unable to get the sand, which was in the sample, uniformly distributed, so the ash content is too low as represented in the analysis of the food. For the sake of comparison it may be stated that the nutritive ratio of green cowpea vine is 1 :5.1.

Another experiment similar to the one just described was begun January 7, 1901, in which velvet bean hay was used. The hay was gathered in October and was of inferior quality as it was collected too late in the season. This was the only material available at the time of starting the experiment, though it was not known until after the experiment was completed that the hay was so inferior as the analysis showed it to be. In this experiment the period continued only five days as one of the animals began to develop abnormal symptoms on the fifth day. Below are given the results:

TABLE NO. 2. DIGESTION OF VELVET BEAN HAY; SHOWING THE WEIGHT IN OUNCES OF THE MATERIAL AND CONSTITUENTS FED, WASTED, CONSUMED AND EXCRETED, TOGETHER WITH THE PERCENTAGE OF EACH DIGESTED, AND THE NUTRITIVE RATIO.

STEER NO. 1

	Total	Dry Matter	Protein	Fats	Fiber	Ash	Nitrogen free Extract
Ounces fed	1128	1046	89.9	17.5	452.8	36.9	448.9
Ounces wasted	280	251.2	14.3	3.0	120.4	8.0	105.5
Ounces consumed	848	794.8	75.6	14.5	332.4	28.9	343.4
Ounces excreted	840	246.2	28.0	3.6	86.3	25.9	102.4
Ounces digested	......	548.6	47.6	10.9	246.1	3.0	241.0
Percentage digested	....	69.0	63.0	75.1	74.0	10.4	70.2

Nutritive ratio.......................... 1 : 12

STEER NO. 2.

Ounces fed	1148	1064.5	91.5	17.8	460.8	37.7	456.7
Ounces wasted	340	309.9	18.9	4.3	149.1	12.7	124.9
Ounces consumed	808	754.6	72.6	13.5	311.7	25.0	331.8
Ounces excreted	668	155.1	18.4	2.4	56.2	16.5	61.6
Ounces digested	....	599.5	54.2	11.1	255.5	8.5	270.2
Percentage digested	....	79.4	74.6	82.2	81.9	30.4	81.2

Nutritive ratio.......................... 1 : 11.4

The hay used in the above experiment had the following composition:

Water	7.27	per cent
Protein	7.97	per cent
Fats	1.55	per cent
Fiber	40.14	per cent
Ash	3.28	per cent
Nitrogen free extract	39.79	per cent

It will at once be seen that this hay is much inferior in composition to hay cut at the proper season by comparing the above figures with those given later under laboratory number 1113. It will be observed that the digestive, coefficients obtained with the two animals differ considerably, which is not entirely unexpected since the condition of an animal has much influence on its digestion. The experiment was closed one day earlier than intended on account of Steer No. 1 developing abnormal symptoms. The results obtained with Steer No. 2 perhaps more nearly represent the digestive coefficients of the hay. The nutritive ratio as found with Steer No. 1 of the hay used is 1 :12 while with Steer No. 2 it is 1 :11.4. By using the digestive coefficients obtained in the above experiment and applying them to a better hay such as No. 1113 the analysis of which follows, the nutritive ratio becomes 1 :6.2 according to figures from Steer No. 1, and 1 :5.9 according to figures from Steer No. 2. We may safely act on the assumption that the nutritive ratio of good velvet bean hay is 1 :6. We hope to repeat this experiment with a good grade of hay some time in the near future. The nutritive ratio of good cow pea hay is 1 :4.7.

TIME FOR CUTTING VELVET BEAN HAY.

In order to form some idea as to the best time to harvest velvet bean vines for hay eight samples were collected at different stages of growth, dried and analyzed.

Laboratory No. 1111, cut September 22, 1899, in bloom.

Laboratory No. 1112, cut September 29, 1899, pods forming.

Laboratory No. 1113, cut October 9, 1899, pods well formed.

Laboratory No. 1114, cut October 13, 1899, pods swelling.

Laboratory No. 1115, cut October 20, 1899, pods half matured.

Laboratory No. 1116, cut October 27, 1899, pods nearly matured.

Laboratory 1117, cut November 3, 1899, pods matured.

Laboratory No. 1118, cut November 10, 1899, vine and pods very tough.

The analyses of these samples are here given and for the sake of comparison the results are calculated to the water free basis.

TABLE NO. 3 SHOWING THE PERCENTAGE COMPOSITION OF VELVET BEAN HAY CUT AT DIFFERENT STAGES OF GROWTH.

Laboratory No.	Protein	Fats	Crude Fiber	Ash	Nitrogen free Extract	Dry Matter in Original Material
1111	15.20	1.33	40.17	6.63	36.67	27.1
1112	14.34	2.12	36.26	5.90	41.38	30.6
1113	14.79	1.25	40·32	7.21	36.43	25.2
1114	15.62	1.82	32.21	6.16	44.19	29.9
1115	15.51	2.11	31.23	6.55	44.60	27.8
1116	13.24	2.31	31.72	6.88	46.35	30.2
1117	13.65	3.07	31·17	6.18	45.93	28.0
1118	14.22	3.42	28.41	6.89	47.06	31.6

It would be manifestly unwise to attempt to draw definite conclusions from only one set of analyses of this character, as inferences to be of value must be drawn from a large number of results. The results given seem to bear out the idea that during the last month of the plant's life no great amount of additional material is produced but that the material in the vine undergoes considerable change. Certain elements in the vine are drawn upon and stored up in the seeds where it becomes available to the young plants when the seeds germinate.

These analyses show the progress of such a change to a certain extent. It will be seen that the protein content remains very nearly constant though it is well known that it is largely transferred to the seeds. There is a gradual increase in the fat content so that the quantity is about doubled during the period. On the other hand, there is a gradual decrease of the fiber as the plant approaches maturity and a constant increase of the nitrogen free extract. The mineral matter or ash suffers little change. It appears in this case that the fiber is converted into what is termed nitrogen free extract which is a term applied to a number of substances as starch, sugars, gums, etc.

Upon taking the physical condition of the hay produced into consideration with the above results the vine should not be cut later than at the condition represented by No. 1113. In other words, the proper time for harvesting is from the time the bloom appears until before the pod begins to show the formation of the seeds within.

VELVET BEAN AS A FERTILIZER.

We are constantly receiving inquirie as to whether ground velvet bean is good for use as a fertilizer. The reply is that the food value of the ground bean is too great for one to profitably use it for such a purpose. If one can make no use of it as a food, it would be more economical to sell the material as such and purchase fertilizer with the proceeds of the sale. The following analyses were made which give a fair idea of the fertilizing value of the ground bean and pod, and also of the hulls alone.

LABORATORY NO. 1081. ANALYSIS OF GROUND VELVET BEAN AND POD.

Moisture	12.28 per cent.
Nitrogen	2.74 per cent.
Potash, K_2O	1.59 per cent.
Phosphoric acid, P_2O_5	0.69 per cent

LABORATORY NO. 1082. ANALYSIS OF VELVET BEAN HULLS.

Moisture	11.62 per cent.
Nitrogen	1.08 per cent.
Potash, K_2O	2.16 per cent.
Phosphoric acid P_2O_5	1.87 per cent.

From the above analysis we find that one ton of beans in the pod contains 54.8 pounds of nitrogen, 31.8 pounds of potash, and 13.8 pounds of phosphoric acid, which gives it a fertilizing value of from ten to eleven dollars.

Instead of grinding the material it may be worked up into a compost.

THE BEAN AS FOOD.

I have little personal knowledge as to how stock relish the ground beans but have been informed by several parties that in many cases stock seem reluctant to eat the material at first, but upon becoming accustomed to it, eat it greedily.

On account of the toughness of the bean it should be ground before feeding. Some even cook the material previous to feeding and claim that cattle prefer it thus prepared. In order to reduce the cost of handling, some turn their stock and swine into the field to feed upon the bean. Unfortunately the only digestion experiment we have undertaken with the ground bean proved a failure and was not completed, so it is not possible to say what percentage of the different constituents in it is digestible. We hope later to determine its nutritive ratio so that its exact feeding value may be known. The following analyses are given which may prove of some service and for the present the digestive coefficients may be regarded about the same as those of the cowpea.

LABORATORY NO. 1081. PROXIMATE ANALYSIS OF GROUND VELVET BEAN AND POD.

Water	12.28	per cent.
Protein	17.13	per cent.
Fats	4.61	per cent.
Fiber	14.25	per cent.
Ash	4.01	per cent.
Nitrogen free extract	47.72	per cent.

LABORATORY NO. 1083. PROXIMATE ANALYSIS OF SHELLED VELVET BEAN.

Water	11.46	per cent.
Protein	22.69	per cent.
Fats	6.60	per cent.
Fiber	7.56	per cent.
Ash	3.16	per cent.
Nitrogen free extract	48.53	per cent.

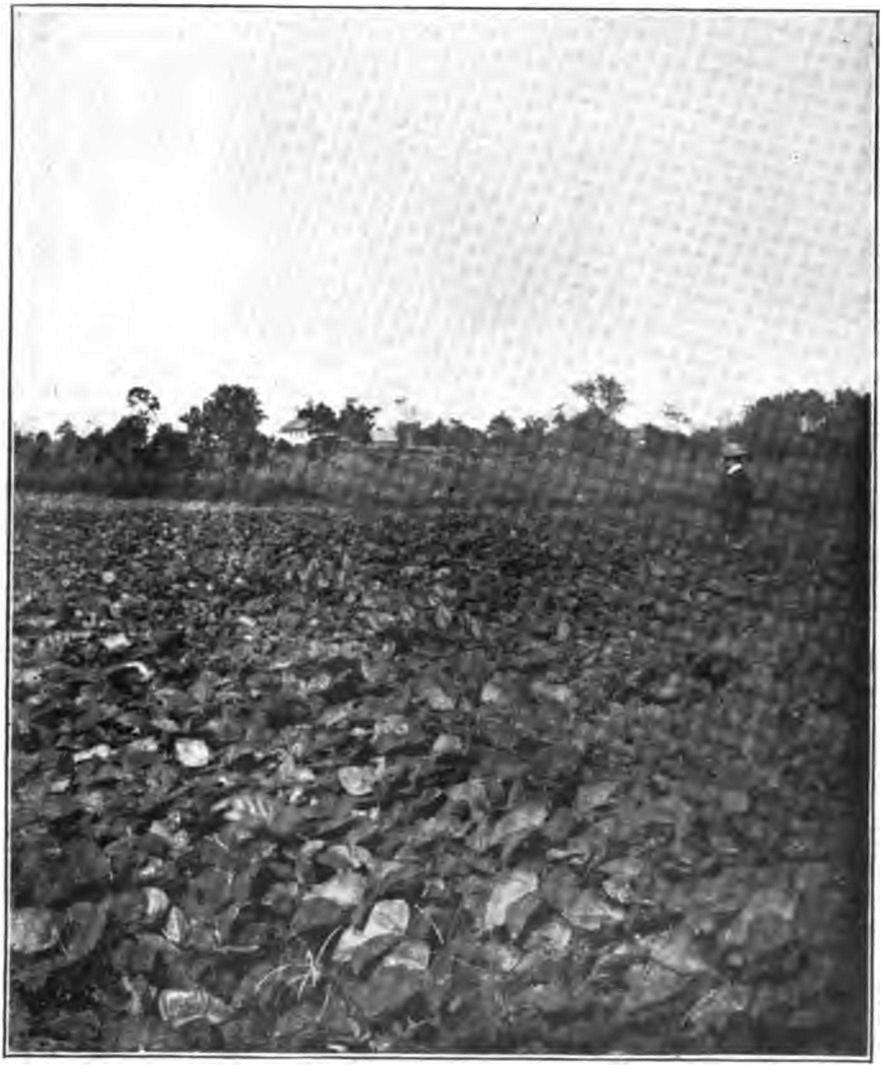

FIG. V.

VELVET BEAN AS A COVER CROP.

The plant in some respects makes an excellent cover crop. The dense growth protects the ground from the sun and crowds out objectionable grasses and weeds. It has proved a source of annoyance to some in their orchards on account of the tendency it has to climb and take possession of the trees. However, this may be avoided by proper planting and attention so as to prevent the vines reaching the trees. An objection advanced by Professor Hume to using this plant in orange orchards is that it acts as a harbor for one of the Soldier Bug family which turns his attention to the trees after the vine is dead.

VELVET BEAN AS AN ORNAMENTAL.

In this climate where it is essential to have our porches protected from the sun the velvet bean, on account of its great growth is very much in favor. This was its only use in the state for nearly twenty years. Not only does it make a dense shade but it is quite an attractive vine, the blossom as shown in cut No. II is very pleasing and the pods too are attractive, the common name of the plant being derived from the appearance of the pod.

In closing I wish to express my thanks to Dr. H. E. Stockbridge for placing at my disposal the animals and material with which to make the digestion experiments. I wish to acknowledge my appreciation of service rendered by H. Harold Hume for taking photographs from which the cuts were made and for the description of the plant. I am also indebted to A. W. Blair for the careful execution of the greater part of the analytical work in this bulletin.

THE ILLUSTRATIONS.

The frontispiece is from a photograph of the velvet bean seeds.

No. II represents the leaf, flower, and fruit in the pod.

No. III is from a photograph of the root illustrating the nodules formed through the agency of the bacteria.

No. IV shows the actual size of some of the nodules.

No. V is from a photograph of a field of velvet beans.